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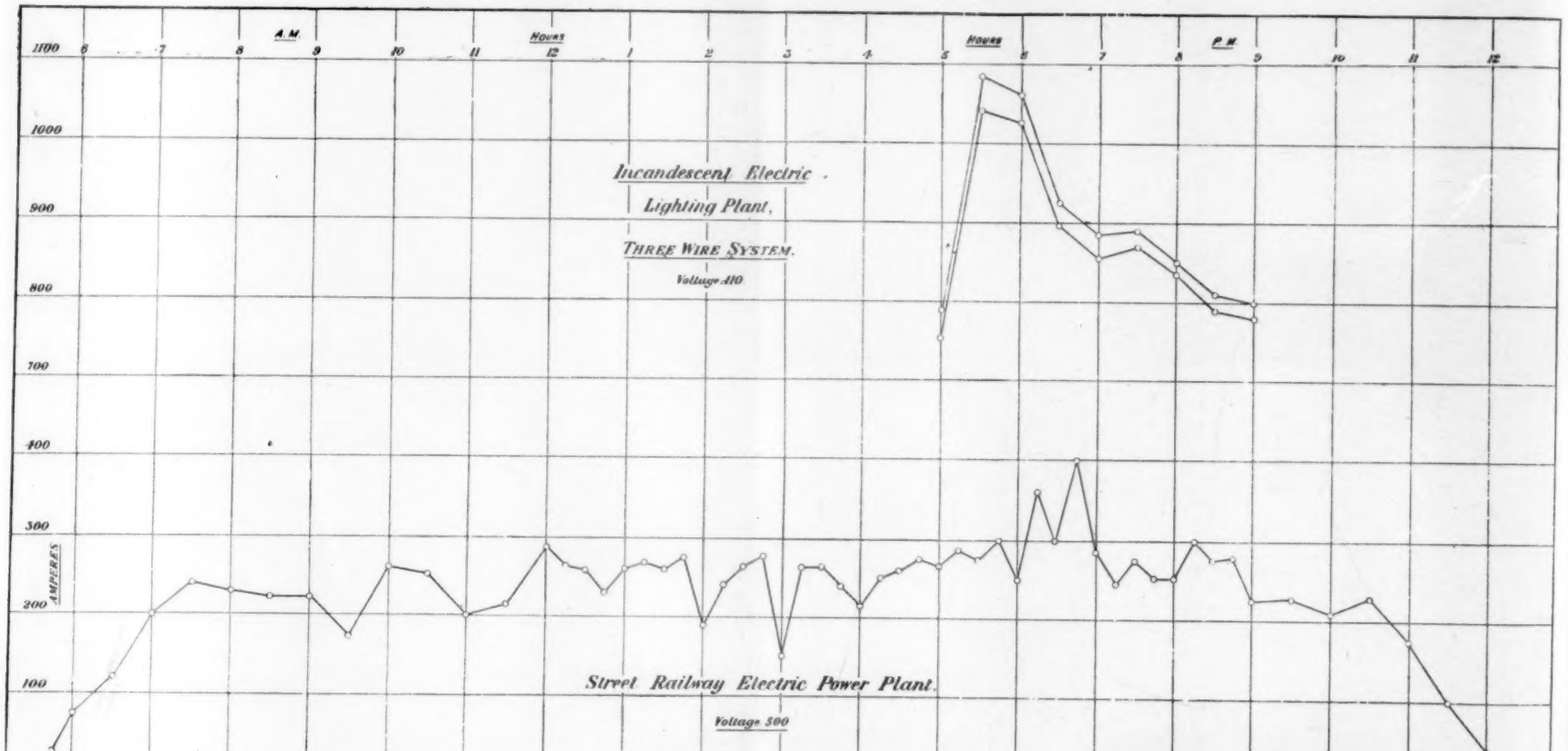
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P.M.
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11
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Incandescent Electric
Lighting Plant.
THREE WIRE SYSTEM.
Voltage 110
Street Railway Electric Power Plant.
Voltage 500

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## THE ELECTRIC TRANSMISSION OF POWER.


BY EUGENE GRIFFIN.


[*A lecture delivered before the Franklin Institute, February 29, 1892.*]

Although the use of electricity for power purposes has increased enormously during the past three years—and there are few, if any, who do not daily see this power in operation—it is a surprising fact that many, perhaps the majority of mankind, do not realize that electricity is not an initial power, but only a convenient form into which energy may be transformed for transmission to some distant point. The newspapers speak of electricity supplanting steam. This is not true in the sense in which the words are used. Electric motors may supplant steam locomotives as the immediate power for hauling cars on railroads, but the steam-power is simply transferred from the locomotive to a large stationary engine at some central station where it

runs the dynamos, and is by no means eliminated from the problem.

The average layman does not reflect that we must have some means of generating electricity, and that the usual method is the application of steam-power to a dynamo. In one sense we must go back to the sun as the original source of energy. For thousands of years the sun has been storing up energy in the form of coal, and we are now using this stored energy for practical purposes. Every lump of coal contains the potentiality of a given quantity of horse-power, or rather from this coal may be obtained a given amount of energy which we measure in units of horse-power. We convert this energy into steam in the boilers, we again convert it into mechanical motion in the engine, again it is changed into electricity in the dynamo and goes out over the wires to be once more transformed into light, heat or motion.

The advantages of generating power in one place to use in another or in several other places, are too many and too obvious to require consideration. In many cases it is absolutely necessary to generate the power at some distant point. In case of waterfalls we have the power existing and running to waste and it is only necessary to utilize it as it is. We may, by pipes, canals and conduits, conduct this water-power to the place where we want to use it, but we can only conduct it down hill. Steam-power can be converted into mechanical power and by belts and shafting carried in any direction, but the distance is limited and the loss in power rapidly increases with the distance. Electric power can be carried in the wires in any direction, up or down, around corners, underground, in the air, wherever the conditions are most favorable, and can be carried longer distances with less loss than any other form of energy. These advantages are so manifest and so important that it is only surprising that electric energy is not more generally used than it is.

Electrical energy is manifested in many ways and is generated by numerous methods; but the only practical method of generation with which we need be concerned is the dynamo; *i.e.*, closed wire coils revolving in a magnetic

field. There are dynamos and dynamos, and it may be well to consider for a moment the different kinds of current which they generate. Dynamos are classified in many ways, as shunt wound, self exciting, separately excited, etc., but the only differences that I care to examine now are those which affect the character of the current produced. The alternating machine is a dynamo in which electric currents are generated in the armature coils, as these coils approach, come opposite to and recede from the magnetic fields of one or more magnets. The ordinary machines have six or more electric magnets placed around the periphery of the frame, and the armature turns in close proximity to the magnets and the field coils which surround the iron cores and form part of the magnets. The electrical impulse or current generated in the armature coil as it approaches a magnet, is in one direction, and as it recedes from the magnet is in the other direction; and so we have a series of impulses alternating in direction, and which for comparative purposes we call positive and negative. Assuming a neutral line, we represent an alternating current graphically by a wave line with equal ordinates above and below the axis. In the direct-current dynamo we commutate the current; *i. e.*, we so arrange the contacts or connections with the wire that leads the current away from the dynamo that these contacts change as the impulses change, so that the impulses are always in the same direction in the lead wire, and we have a constant or direct current which we represent graphically by a straight line.

If the constant current dynamo with its two fixed brushes be supplied with a third brush so arranged that it revolves about the commutator with greater or less rapidity, we have a peculiar result which we call a pulsating direct current. This is used practically to operate a rock drill constructed on the solenoid principle, as follows:

The upper and lower brushes are fixed; the third or revolving brush is shown in its neutral position. When in this position, or when it has revolved 180° from this position there is manifestly no current in the third or middle wire. As the revolving brush approaches the upper brush, the

middle wire takes part of the current of the upper wire and as it approaches the lower brush it takes part of the current of the lower wire. The result is an alternation of pulsations through the upper and lower halves of the solenoid varying in rapidity directly with the rapidity of rotation of the third brush. The drill in the solenoid is drawn up and down with rapidity dependent upon the rapidity of the electrical impulses. This peculiar current is graphically represented on accompanying plate.

You have all doubtless heard of the long-distance power transmission installation recently exhibited at the Frankfort Exhibition in Germany. In this installation still another kind of current is used, called the three-phase current. Three separate impulses are generated in each revolution of the armature, each lagging 120° behind the previous impulse. This dynamo is practically an alternating dynamo and the current generated bears somewhat the same relation to the ordinary alternating current as the pulsating direct current does to the ordinary simple constant current obtained from a two-brush machine. The three-phase current is graphically represented on accompanying plate.

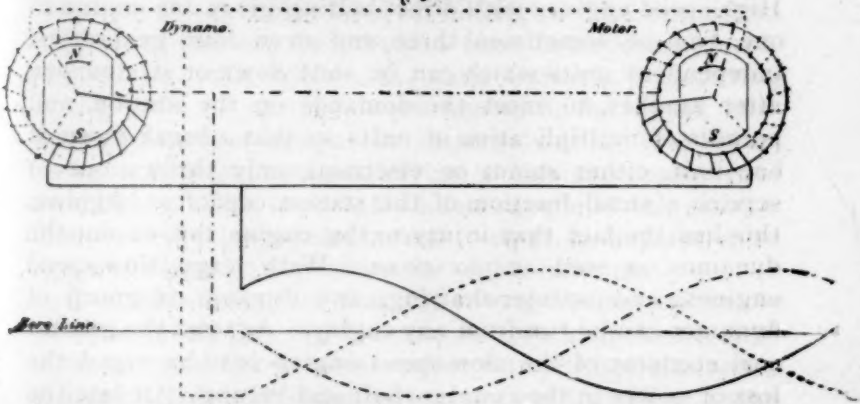
In the electrical transmission of power are involved four elements:

(1) The original power.
(2) The generator.
(3) The line.
(4) The motor.

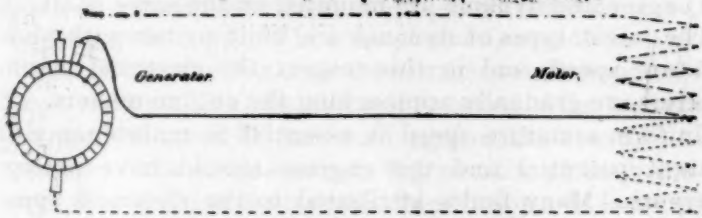
The original power is usually steam; sometimes water. If the power consumed at the other end of the line is constant; *i. e.*, if the load on the engine is constant, or if the changes in load are gradual, the problem is simple, so far as the steam engine is concerned, and any of the ordinary types of engine will do the work. For street railway and similar work where the loads are variable, especially strong engines are required to stand the enormous strains resulting from the sudden and very violent fluctuations. The same build of engine which did good work in an electric lighting station was found to be too light for railway work.

Engineers are not yet agreed as to whether high- or low-

***Three Phase System.***

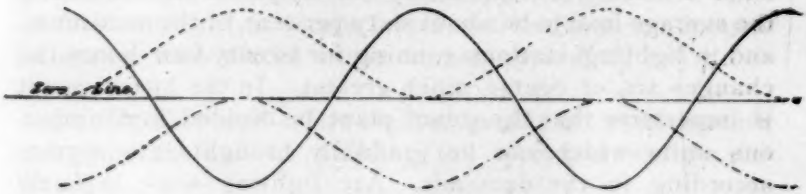



***Van Depoele Pulsating Current System.***




***Currents in two Coils of Motor.***

***Currents in Three Line Wires.***



speed engines are preferable for power stations, but the weight of opinion seems to be in favor of slow speed. High-speed engines with direct belting gives one engine to one, two, or sometimes three and even four generators, independent units which can be shut down or started, one after another, to meet the demands on the station, and permits of multiplication of units so that a break down of one unit, either steam or electrical, only throws out of service a small fraction of the station capacity. Against this lies the fact that injury to the engine throws out the dynamos as well as *vice versa*. With large, slow-speed engines, and counter-shafting, any dynamo or group of dynamos can be run from any engine. Against the greater coal economy of the slow-speed engine is to be urged the loss of power in the counter-shaft and belting. Of late the method of direct coupling, making the engine and dynamo practically one machine, is meeting with more favor and for large sized generators this method undoubtedly has a future. The engine and dynamo are mounted on the same shaft.

The latest types of dynamo are built to run with slow armature speed, and in this respect the electrical manufacturers are gradually approaching the engine makers.

Uniform armature speed is essential to maintenance of constant potential and the engines should have perfect governors. Many faults attributed to the electrical apparatus have been found on investigation to be really due to poor engines, imperfect governors, slipping belts, low steam pressure or other cause remote from the electrical apparatus.

Engines work most economically under full load. Unfortunately constant loads are not the rule in electrical work, and as the loads vary the mean must be somewhat below full load. A mean of several electric railway power stations shows the average load to be about sixty per cent. of the maximum, and in lighting stations running for twenty-four hours the changes are, of course, much greater. In the latter case it is imperative that the steam plant be divided into numerous units which can be gradually brought into service according to the demands. Arc lighting work is fairly

constant. Street lights burn all night or on moonlight schedules, and are all started and stopped at the same time. Commercial lights may burn till midnight. The limitations are known and can be provided for. Incandescent work, particularly with meters, is more variable. Referring to the plate of curves shown herewith, the upper lines show the current output in ampères during four hours for an incandescent station having a maximum capacity of 4,000 lights. This is probably a fair sample of this service. The lower line shows the current output in ampères of an electric railway power station for eighteen hours.

From this it appears that, the average being well below the maximum, the engines are not working to the best advantage and the greatest coal economy is not attainable. In Europe, this is obviated to some extent by adding a storage battery to the station equipment. The steam plant is then proportioned to the mean demand for power and runs constantly at full load. When the demand for power falls below this mean, the extra current generated is directed into the storage battery. When the demand exceeds the capacity of the engines and dynamos the extra current is supplied from the batteries. The cost and maintenance of the batteries in this method must be balanced against the cost and maintenance of the extra steam and generator plant in the first method, and the less economical operation. It is a striking fact that storage batteries are used to a very large extent in foreign stations (not necessarily in all cases in the way above indicated) and rarely, if at all, used in this country. One would suppose that the actual results would long since have determined in which method true economy is to be found, but so far the engineers on the two sides of the Atlantic have not been able to agree. The practice differs also in another respect. In Europe rope belting is largely used, while in this country it is rarely found and has been condemned in one or two places where it has apparently had a fair trial.

(2) *The Generator.*—The kind of generator used depends upon the method of utilizing the electrical energy produced.

The arc lighting dynamo is made to generate a current of constant quantity and potential varyir g with the number of lamps on the machine. The incandescent direct-current dynamo generates a current of constant potential and quantity varying with the number of lights. The railway or ordinary power generator is similar to the incandescent direct-current machine. The alternating-current dynamo produces a current suitable for incandescent lighting, but so far it has not been made available for power work as the alternating motor has little torque and therefore cannot start under a load. The pulsating direct-current machine is the ordinary direct incandescent dynamo with a third brush added and is used as before stated. The three-phase current dynamo has no commutator, runs noiselessly, and can be used for power purposes as the motor has sufficient torque to start with a load.

In the synchronous method of transmitting power by alternating currents, it is necessary to start the motor by some exterior power; but if proper arrangements are made, the starting is no more difficult or tedious an operation than the starting of a large Corliss steam plant.

The synchronous motor when overloaded "lies down" and declines to do any work at all until the load is reduced to proper limits.

The synchronous alternating motor has an excellent quality in which it is only equalled by the plain shunt-wound motor of the every-day electric lighting station. It regulates perfectly as to speed, keeping in step, within the limits of its capacity, with the generator which drives it.

The non-synchronous type of motor, in connection with the three-phase current, presents many features of superiority over the synchronous, in that its speed will not vary more than a few per cent. from light to full load, and also from the fact that it will start under full load, and requires no exciting current. A field is set up by three conductors conveying currents of three-phase character, in a laminated iron mass, which field is made to rotate, and drags around a movable iron armature on which is a system of closed coils, or coils which can be closed, these coils having strong

currents induced in them by the moving lines of the field. Thus, the rotating magnetic lines in cutting the armature conductor, push the conductor along by virtue of the reaction of opposing currents set up in the conductors of the armature, or closed circuits. These motors are not capable of being used as generators when revolved by exterior power. The great advantages of this method are that the motors can be started and stopped at will, and have no commutators.

The sizes of the dynamos have greatly increased in the last three years. We have now seventy-light arc dynamos, 2,800-light direct incandescent machines; Ferranti's 100,000, sixteen candle-power light alternating (10,000 horse-power) dynamos; and 670 horse-power generators for power use.

The Thomson-Houston Company are now building seventeen of these large power dynamos for the West End Street Railway of Boston.

In increasing the sizes of dynamos a change from the bi-polar type of the smaller dynamos has been found neces sary, and the large machines are made with not less than four poles. Slower speed of the armature is a natural advantage, and many other improvements are to be found in the latest type of power dynamos.

The size of the dynamo should be proportioned to the total work at the station. There should never be less than two generator units, and preferable more. With a total of 250 horse-power, it would be poor practice to have but one 250-horse-power dynamo. Three eighties would be far preferable. With a total of 2,000 horse-power, it would be poor practice to have twenty-five eighty-horse-power dynamos. Eight 250's would be preferable.

The switchboard should be provided with every possible safety device to automatically prevent overloading of the dynamos, injury to the machines from lightning, and to automatically throw off the current in case of short circuit on the line resulting from crosses with the line wires or accidents of such nature.

(3) *The Line.*—Having converted the power into the form of electrical energy, we now must transport it to

the place where it is to be used. The line wires do this. For lighting, the lamp is the place where the energy is to be utilized, and the wire leading from the dynamo to the lamp may be thoroughly insulated and placed overhead, underground or anywhere so far as fulfilling its duty in this respect. In railway work, we want the current at variable points over many miles of streets, and this can only be obtained by the use of bare conductors and brushing, sliding, or rolling contacts. It is this essential difference between railway and lighting work that prevents us from placing the railway wire underground as we do the lighting wire. The railway wire must be bare in order that we may obtain electrical contact every fraction of inch from one end to the other. To place this bare wire in a hole in the ground and keep it securely insulated from the ground, to keep the width of the slot down to safe dimensions, and yet work the conducting plow which must be absolutely insulated from both sides of the slot, has been found to be no easy task. Every practical trial in this country has failed.

(4) *The Motor.*—The motor is simply the dynamo reversed in its operation, and the various forms are those best suited to the varying conditions of use.

Several different systems have been successfully used for long distance transmission, but the alternating has proved most successful. The difficulty of handling a potential of over 2,000 volts direct current has hindered progress in this direction. The sparking between the segments of the commutators in these dynamos and the difficulty of insulating for such high pressure have been sources of trouble. In the alternating, where a low potential can be developed in the dynamo, and by the use of step-up transformers, raised to any desired height, this difficulty is avoided.

The following are some of the actual examples of electrical transmission which we find abroad and at home.

Many of the large water-falls of Europe, notably of Switzerland, are now being utilized, and the neighboring cities and towns lighted by electricity, transmitted distances ranging up to 112 miles.

Probably the most notable plant ever constructed is that of the Frankfort Exhibition, where over 300 horse-power was transmitted 112 miles by means of three slender bare wires No. 4 B and S gauge.

Lauffen, where the generating station was located, is situated on the Necker, a branch of the Rhine, and the enormous water-power was utilized to generate 300 horse-power of electrical energy at a tension of from 16,000 to 30,000 volts.

At Lauffen step-up transformers were used to increase the potential from the fifty volts of the dynamos to these very high pressures used, and at the other end of the line, namely, in the grounds of the electrical exhibit, step-down transformers re-converted the pressure to a point where it could be utilized for both light and power uses.

An immense bank of lamps, wired up in series, gave evidence of the high voltage of the line. In only one case did the insulation break down, and that was at a strain of 30,000 volts.

An interesting feature of the installation was the supplying of an artificial cascade, thirty feet high, with water pumped by means of the electrical current, thus completing the cycle of changes. The experiment was undertaken more as a matter of scientific investigation than an attempt at commercial success. An efficiency of seventy-four per cent., however, was obtained.

The cost of the installation per effective horse-power based on the assumption of 300 horse-power delivered at Frankfort, was a little over $300, of which the cost of the line involved $210.

During the progress of the exhibition, the plant was run at a potential of 16,000 volts. At the close, however, experiments were made at a very much higher pressure. The insulators were made in three sections. The porcelain top was flat with a deep groove to hold the wire, and underneath a saucer-shaped receptacle. Beneath this was another receptacle of larger breadth and depth, and under this still another. All were filled with oil. On final experiments the pressure was increased to 20,000 and finally 30,000 volts.

Though none of the insulators gave way a plate of glass was easily punctured. It is believed that these insulators, somewhat modified in form, can readily be made to stand a pressure of 50,000 volts.

During the experiments regular readings were taken at both ends of the line, and voltmeter readings were taken between one conductor and the neutral point in each of the three circuits, which averaged fifty-four volts, the current readings being 500, 490 and 500 ampères, respectively, in the primary circuits. The mean electric power delivered to the line was 80,500 watts. At the same time the Frankfort end of the line delivered current for 1,060 incandescent lamps of sixteen candle-power which absorbed about 58,000 watts. These figures give the seventy-four per cent. efficiency which it is claimed is low owing to the lag. Wet weather was not found to appreciably affect the working of the line. The losses due to condenser action of the conductors was also found to be very small.

A description of the Lauffen-Frankfort transmission plant is not complete without brief reference to the permanent transmission of power from this point; to-wit: Lauffen to Heilbronn, a distance of seven and one-half miles. The plant is owned by the Lauffen-Portland Cement Company, and the power, besides running their work, also supplies the city of Heilbronn with light. The power plant is of 1,500 horse-power capacity, of which 600 horse-power is used for the cement works, leaving 900 horse-power for the supply of light and power. The alternating current system is used on account of the great distance the current is transmitted. A 300 horse-power rotary-current dynamo with a capacity of 4,000 ampères at fifty volts is used. This current is transformed to 5,000 volts. The transmission is by three sets of bare wires, ·24 inch in diameter carried on overhead poles with oil insulators. An ingenious device for protection against lightning is the placing of an ordinary barb wire above the wires on the pole, and connecting with earth at frequent intervals. At the outskirts of the town of Heilbronn the current passes through a large transformer similar in type to that at the Lauffen end.

which transforms the current down from 5,000 to 1,500 volts. From here it is conveyed by concentric cables underground. At more central points other transformers are located which reduce the potential down to its final pressure of 100 volts, at which it is supplied to customers.

The total loss in the seven and one-half miles of leads and in the double transformation is said to be only twenty per cent., 160,000 watts of the 200,000 generated at Lauffen being available to customers. This is sufficient for 3,200 incandescent lamps of sixteen candle-power.

Another interesting plant is the generating station located at the villa town of Tivoli, Italy, which is situated in the Sabine Hills eighteen and one-half miles from Rome. The practically unlimited water-power of the river Amene is used at this point to drive water-wheels. The current generated is utilized for light and power in Rome.

The motive-power is derived from a water flow of about 132 cubic feet under a head of 157 feet.

Six turbines of 300 horse-power each, are coupled direct to alternating dynamos, 230,000 watts capacity, at 170 revolutions a minute.

In addition there are three direct-current machines, each coupled to a turbine making 375 revolutions, which are used as exciters for the alternators.

At full load, a potential of 5,100 volts is used. The current is conducted by means of four bare copper wires (between Nos. 7 and 8 B and S gauge), carried on iron poles with oil insulators.

The drop in potential amounts to twenty per cent. on a line of 18·4 miles (circuit 36·8 miles). At the outskirt of Rome near Porta Pia, is located the distributing tower in which the current is transformed from the pressure of 5,000 to one of 2,000 volts. This is again reduced at centrally-located points to 100 volts, at which it is furnished customers.

When fully completed the central station of Rome with its 5,000 horse-power capacity will be the second largest lighting plant of Europe, Berlin having the largest.

The town of Pontresina is situated in the Engadin Valley, at an elevation of some 6,000 feet above the sea.

The lighting plant was designed and constructed by the firm of R. Alioth et Cie, of Basle, and is one of the somewhat uncommon direct-current transformer systems.

About four miles south of Pontresina, at the base of the famous Morteratsch glacier, are the falls of the Bernina.

A portion of the stream above the falls is diverted to a small reservoir from which it is conveyed by a cast-iron pipe to the power station at the foot of the mountain. It is used to drive the turbines to which the dynamos are coupled.

The maximum rate of water discharge is over seventy gallons a second with a head of 420 feet.

Seventy-five horse-power high pressure turbines, built by Escher, Neyss et Cie, of Zurich, are used, each connected independently to a primary dynamo by flexible couplings. The generators have each a capacity of thirty-four ampères, (1,500 volts), or 51,000 watts at 500 revolutions, and are of the four-pole type, series wound.

The turbines are equipped with automatic regulators which maintain a constant speed, this insuring a constant potential at the transforming station under all loads. Three machines are run in series giving a combined capacity of thirty-four ampères, 4,500 volts, 153,000 watts, a fourth being held in reserve in case of breakage. The primary current is conducted by a No. 4 copper wire. Oil insulators are used.

In the transforming station, situated in the centre of Pontresina, the current passes first through meters and safety devices placed on the switchboard, then to the four motor dynamos which are connected in series, the secondary lines being connected in multiple with the service lines.

The number of transformers at work is controlled by a multipole switch, the number running corresponding to the number of generators in operation.

The difference in the construction of the "direct-current transformer" or "motor dynamo" from the ordinary dynamo, consists in the presence of two distinct windings on the

armature each connected to a separate commutator located at the two extremes. Through one set of windings the primary current is passed, causing the armature to revolve, producing the motor action, while in the other a current is generated and conveyed to the service line—the voltage of this latter depending on the same conditions that govern any dynamo.

The current of the secondary, which delivers 280 ampères at 130 volts, is distributed by a second switchboard, fully equipped with all the necessary regulating apparatus, meters and safety devices.

One hundred and twenty arc lamps are used, and the greatest load is 840 ampères at 130 volts. Over 1,700 incandescent lamps of different candle-power are on the circuit beside the arc lamps used for street lighting.

Streets, hotels and private houses are lighted. The plant was erected by the consumers, and is run on the co-operative plan. Every citizen can join by paying his actual part of the expense. The company is in touch with the township from which it derives its water-power rights, and in return it furnishes the street lighting free.

In spite of the distance between the power station and the point of consumption, four miles, the direct-current system was adopted on account of its safety, and the many advantages it afforded in making it possible to add accumulators to the system, thus increasing the capacity at the heavy period of consumption, and also its greater adaptability for motor service.

A rather novel plant is being constructed at Kioto, Japan. In this case, the water of a lake some nine or ten miles distant from the city, will be brought through pipes to a distance of about two miles from the city limits. Here it will be used to drive electric generators. The power will be used throughout the city for factories and for general lighting and power work. The motors farthest from the generating station will be some four miles distant. Pelton water-wheels of 120 horse-power are to be utilized.

It is estimated that there are fully 200 power stations

operated by water-power in Switzerland alone. Even in the "Dark Continent" of Africa they have long distance electric power transmission plants. The Forbes Cliff Mining Company, of Transvaal, operate Pelton water-wheels coupled direct to Edison dynamos aggregating over 200 horse-power, which is transmitted four miles. The efficiency of the entire system is over seventy per cent.

At St. Brieux, Côtes de Nord, France, two 1,300-light Thomson-Houston alternators are driven by two Hercules turbines of the vertical type, one a 125 horse-power, and the other 150 horse-power. An interesting characteristic of this plant is that the alternators are run in multiple upon the same circuit. The distance from the central station to the centre of distribution is some eight and one-half miles, and the pressure employed 2,000 volts. It is interesting to note that the wires used to convey the current for 2,600 sixteen candle-power incandescent lamps over the distance of eight and one-half miles are ·31 of an inch in diameter.

A power transmission plant at Ayonnax, eastern France, has been in operation since March, 1890. Power is obtained from a 1,750 horse-power fall, five miles from town, where two 105 kilowatt machines are coupled direct to two horizontal turbines. Current is transmitted on the three-wire system to two 120 horse-power motors, driving directly two 125 volt, 600 ampère dynamos. The commercial efficiency is said to be 76·2 per cent.

The power of the 180-foot fall at St. Lorenzen, Austria, will be utilized for running the works of Franz Company, of Marburg, eighteen miles distant. Of the 600 horse-power available, it is expected to utilize about 450 at the works. Total cost of plant estimated at about $110,000.

An Anglo-Swiss syndicate has been formed to utilize the power of the Rhine at Laufenberg for the electrical transmission of power. It is intended to make a canal one mile long, and it is estimated that some 7,000 horse-power will be available.

The 45,000 light station at Paris, supplying the Place Clichy sector, has three floors with superficial area of 19,800 square feet. Three 150 horse-power Armington & Sims

engines belted to two shunt-wound dynamos, and three 500 horse-power Corliss engines running at sixty-four revolutions, and coupled direct to 350 kilowatt (700 ampère, 500 volts) eight-pole machines, armatures eleven feet in diameter, run during the day; a 250-cell battery of Laurent-Cely accumulators supplies current during the night. The district has an area of nearly two square miles.

In Guatemala, Central America, a combined arc and incan descent plant has been operated by water-power since the year 1887. Part of the plant consists of two Thomson-Houston 1,500 light alternators. The station is three and three-fourths miles distant from the city. Twenty-one inch Rodney-Hunt turbines of 250 horse-power are used, driving the dynamos by a counter-shafting. The remainder of the plant comprises seven forty-five light 2,000 candle-power arc dynamos, and three eighteen-light machines. This part of the plant is seven and one-half miles away, and receives its power from a fifteen-inch double Rodney-Hunt turbine of 260 horse-power.

The city of Pueblo possesses an electric lighting plant, which is in many ways remarkable. Two hundred arc lights of 1,200 candle-power are run by four fifty-light arc machines in a station some thirteen miles away from the centre of the town. The power is furnished by the river Atoyac, operating a 200 horse-power Leffel double turbine. Each of the four existing circuits is about twenty-six miles in length, and consists of a No. 4 insulated wire. The dam and the masonry of the station itself has been built of fine cut stones, and forms probably one of the most substantial and well-built structures in Mexico.

A contract recently entered into by the Thomson Houston International Electric Company, provides for a plant to be worked by water-power near the town of Pireacicaba, Sao Paulo, Brazil. The system will probably comprise fifty arc lamps of 1,200 candle-power each, and about 2,000 incandescent lamps of the alternating system. In this case the power station will be only about a mile away from the town.

Turning now to the plants in this country, we find that

in the celebrated Comstock Mine, in Nevada, water from the mountain lake has been turned down one of the shafts of the mine for 1,200 feet, and at this depth in the earth a series of specially constructed wheels are located coupled direct to the dynamo machines. This novel plant is still in successful operation. It consists of six generators, ranging from 100 to 120 horse-power capacity each, and six motors of sixty horse-power each.

As so much has been said in the papers recently about the Niagara power plant, the forces exerted by this immense volume of water may be of interest.

Some 21,000,000 cubic feet of water pass over the head of Niagara every minute.

The idea of the great Niagara tunnel is said to have originated with the late Thomas Evershed. The tunnel or tail race, is to extend from the surface of the water level below the falls to a point on Niagara River above the Falls. It is to be connected with the river by means of short surface canals, wheel pits and cross channels.

The power expected to be produced by the capacity of the tunnel will be equal to the water-power of Lawrence, Lowell, Holyoke, Turner Falls, Manchester. Bellows Falls, Lewiston, Me., Oswego, Paterson, Augusta, Ga., Minneapolis, Rochester and Lockport combined.

The method of using the power is to be the same as that in operation upon the hydraulic canal.

The tunnel is to be of a horseshoe section, having a capacity equal to a circle of twenty-five feet in diameter, extending through the solid rock from the water level below the falls to the river above the cataract, a distance of one mile. From this point the tunnel is to continue parallel to the shore of the river one and one half miles more at an average depth of 160 feet below the surface, and about 400 feet from the river, with which it will be connected by surface conduits. The tunnel is used as a tail race, and the great length is necessary to avoid marring the scenery. Plans have been made for a 120,000 horse-power plant.

Crossing over into Ontario, we find that a scheme is

contemplated to utilize the Canadian Falls. The plan is wholly different from that on the American side, and no long tunnel is necessary. Mr. Ferranti has this work in hand.

The papers have discussed a scheme for transmitting power from Niagara to the World's Fair, which involves a distance of 475 miles, which is more than four times that separating Lauffen and Frankfort. Eighty thousand volts is the suggested voltage.

California capitalists were among the first to recognize the value of electrical transmission for mining purposes. A power plant was built by the American River syndicate of El Dorado County, more than two years ago, which utilized the water-power of Rock Creek. The plant consists of an eight-foot Pelton wheel, running under a head of 110 feet with a five and one-half inch nozzle. It has a maxmium capacity of 130 horse-power. The current generated is used at the mills, situated some two miles distant; three centrifugal rolling mills, and a ten-stamp battery and rock breaker being operated. The potential used is 100 volts, and seventy-five per cent. of the power generated is available for duty at the mill. The entire works are further lighted by incandescent lamps. The mills are handling an average of 4,000 pounds of ore per month, and a saving of some sixty per cent. over the former method has been effected.

Other plants are located at Grove Mine in Amador County, Cal., and at the Cœur d'Alene Company's works of Idaho.

Probably in the before-mentioned Lauffen-Frankfort installation, the highest potential yet attempted on a large scale was utilized. There a voltage up to 30,000 volts was obtained, and the insulators were found able to stand the pressure.

It is figured that if an insulation can be made capable of standing 1,000,000 volts, over 30,000 horse-power can be transmitted 500 miles with a 0000 wire with a loss of less than one-half per cent. One ampère at this pressure would transmit 1,250 horse-power.

The application of electricity to steam railroad propulsion is a problem that is now upon us. Since the first of this year the engineers of five of our largest railroad systems have been in consultation with the electric companies in reference to this matter.

We have in course of construction a thirty-two-ton locomotive that can easily run seventy miles an hour, and before the end of the year the power and speed of the electric locomotive will be a demonstrated fact and no longer a theory. It will be easy to demonstrate its economy in many places where it can advantageously replace the steam locomotive; but for long distance runs it cannot at present compete with steam except under unusually favorable conditions; as for example, where there are a succession of water-powers that can be utilized as sources of energy. At present we can only speak of what is to be done. Next year I trust we can point to what has been done.

The application of electric-power to street-car propulsion comes nearer to the masses and is of more direct benefit to mankind than any other application at the present time. It is almost universally acknowledged that the vexed question of "rapid transit" can only be solved by the use of the electric motor. The development in this respect has been enormous.

There are in the United States, according to the census of 1890, sixteen cities of over 200,000 population. There are electric railways in fourteen of these, or in over eighty-seven per cent. There are forty-two cities of from 50,000 to 200,000 population and of these forty-one, or over ninety-seven and one-half per cent. are supplied with electric railways. There are 450 electric railways in the United States at the present time and over 6,400 cars operated by electric-power, and sixty-two more roads are being constructed.

Notwithstanding the constant newspaper statements as to the dangers of the trolley system, we have yet to find a single authenticated instance of death caused by the 500-volt railway current carried in the trolley wires. We have at our office many newspaper clippings alleging

such cases, but upon investigation every one is found to be incorrect, the death, where there is any fatal result, arising from other causes. For example, a workman in Bangor, Me., was painting a building and short circuited an alternating incandescent current through his body, falling from the building and being picked up dead. In the newspapers his death was caused by the trolley, though as a matter of fact he was never near the trolley wire; never came in contact with it. These facts were certified to by the coroner. I was told of a man who fell from a building forty feet to the ground. He struck the trolley wire in such a way as to produce a short circuit which slightly burned his leg. He stated that the trolley wire in all probability saved his life, as it broke his fall.

On the 16th of this month, the Cambridge line of the West End Company in Boston had been in operation just three years. Since February 16, 1889, there have been many additions made to the electrical equipment of the West End Road; until now they have 120 miles equipped electrically and over 300 electric cars in operation.

Last year 119,264,401 passengers were carried on these West End cars, and not one single individual has ever been killed or seriously injured by the trolley current. There have been accidents—very sad accidents. Men, women and children have been run over and killed, but such accidents happen on every road whatever the motive-power, and it is a striking and most significant fact that the insurance companies which insure street railways against loss by accidents find relatively more accidents on horse-car lines than on cable roads, and more accidents on cable roads than on electric roads.

# OLEOMARGARIN.

By Prof. G. C. Caldwell, Cornell University, Ithaca, N. Y.

[*A lecture delivered before the Franklin Institute, January 18, 1892.*]

One of the most interesting groups of chemical compounds, and one of the most important in the arts, is the fatty acid series, so-called because many of its members are attained from fats. These acids, twenty in number, are constructed on the same plan, all of them containing two atoms of oxygen and each differing from its predecessor by $CH_2$ or twice or three times that; all of them have twice as many atoms of hydrogen as of carbon. If we compare acids that are contiguous to one another in the series, we find such close resemblance between them in properties, that it is often very difficult to separate them completely from one another by either physical or chemical methods; but as the composition of these acids gradually changes with each increment of $CH_2$, the properties change also, so that comparing acids widely apart in the series we find very different properties. Formic acid, $HCHO_2$, and acetic acid, $HC_2H_3O_2$, are easily soluble in water, very sour to the taste, quite corrosive on the skin when very concentrated and convertible into vapor without decomposition, so that they can be distilled. Palmitic and stearic acids, $HC_{16}H_{31}O_2$ and $HC_{18}H_{35}O_2$, also closely resemble each other, but differ strikingly from formic and acetic acids. They are quite insoluble in water, have no sour taste, cannot be distilled without decomposition and have no action on the skin, no matter how concentrated they may be.

Out of this series of acids, I select six as possessing special interest in connection with the subject upon which I have chosen to speak to you this evening. Four of these, butyric, caproic, caprylic and capric, are near together in one part of the series; and two, palmitic and stearic, are near together in another part

Intimately associated with both of these groups is an acid of another series, oleic acid.

As is known to all chemists, when any natural fat or fatty oil is heated with soda or potash, and this product is heated with a strong acid, a mixture of fatty acids is obtained, very rarely, if at all any one fatty acid; glycerine is produced in the same operation. Corresponding to each fatty acid is a body called a glyceride; and it is the mixture of these glycerides that constitutes the original fat from which the mixture of fatty acids is produced. The glyceride of butyric acid is called butyrin, of caproic acid, caproin; of palmitic acid, palmitin, and so on.

Nearly all the ordinary natural fats and fatty oils consist essentially of three glycerides, palmatin, stearin and olein. The differences in odor and taste by which they are distinguishable from one another are due to minute quantities of other substances which they contain, and which are also associated with them in their natural, or in their prepared condition. Castor oil, olive oil, tallow and lard are unmistakably different to our senses of taste and smell; but all of them alike consist essentially of palmitin, stearin and olein, this mixture being scented and flavored by the foreign substances just mentioned.

There is an important difference between the fat in milk and some other fats, on the one hand, and the fat of tallow, lard and palm nut oil on the other hand; a distinction all the more interesting since it exists between the fat that is deposited on the carcass, and that which is secreted in the milk of the same animal. Butter and tallow are mostly but mixtures of olein, palmatin and stearin, the same three glycerides that are so widely distributed in the fats everywhere; but butter fat contains, besides, the four other glycerides, butyrin, caproin, caprylin and caprin; but since even these glycerides when purified are as tasteless and odorless as any of the others, none of the odor or flavor of butter can be credited to them.

This being the case, then, it is only natural that the attempt should be made to give a butter flavor and aroma to the more abundant and much cheaper fats of the animal

carcass; it is only a question of transforming the carcass fat into one of the same consistency as that of butter at ordinary temperatures, removing its characteristic flavor, and substituting therefor the butter flavor. The first change is easy enough, consisting as it does simply in taking out a certain proportion of the less fusible stearin and palmitin, so as to leave a residue with a larger proportion of olein, and therefore softer at common temperatures, as butter is softer than tallow; since this odor and flavor are largely due to soluble and volatile foreign substances, steaming and washing the fat will leave a sufficiently odorless and tasteless product as a basis for receiving the desired butter flavor. It is plain that the available quantity of this product from the carcass fat is much larger than the available quantity of the material like which it is to be flavored, the butter fat of milk. How then shall this flavor be imparted?

We know quite well that when it comes to giving the flavor of lemon, strawberry or raspberry to ice cream or cake, not even the shadow of the fruit need be cast over the material to be thus flavored; much less need any of its substance be incorporated with the cream or dough; a chemist in his laboratory can manufacture at least many of these flavoring essences more cheaply than they can be made from the fruits. But I am not aware that any essence of cow's butter has ever yet been prepared. A clean mixture of olein, stearin and palmitin, no matter how carefully the proportions of these three ingredients might be adjusted to secure the right consistency, no matter how deftly colored, would never pass for butter, even with the least fastidious. Therefore, the amount of salable artificial butter that can be made from this olemargarin is limited by the degree of thinness with which real butter fat with its butter flavor can be distributed through it, and produce a resemblance to butter.

Just here a few words in explanation of the terms oleomargarin, margarin and butterin may well be given. In the list of fatty acids margaric acid comes between palmitic and stearic. Originally it was believed that the three glycerides,

palmitin, margarin and stearin, together, made up the less fusible part of all fats; and that a mixture of the four fatty acids, oleic, palmitic, margaric and stearic was obtained, when these fats were saponified and the soap was decomposed by a strong acid. In fact, the three acids, palmitic, margaric and stearic, were apparently separated from one another out of this mixture of acids by repeated re-crystallization; the supposed margaric acid thus obtained refused to change any further by continued treatment of the same kind as that by which it was made; and, as its composition, melting point, specific gravity and solubility were such as might be expected of any acid standing midway between palmitic and stearic acids, no one doubted the existence of this glyceride in these fats. Heintz, in 1852, declared that this was all a mistake, that this supposed margaric acid was only a mixture of palmitic and stearic acids, and that every specimen of so-called margaric acid prepared from fats could be resolved by his method of fractional precipitation into palmitic and stearic acids. Five years later he prepared the real margaric acid in a pure state, by chemical action on spermaceti, possessing all the properties that margaric acid should possess, including, in addition to what the old acid did not possess, a persistent obstinacy against being split up into palmitic and stearic acids.

But while margarin does not occur in natural fats, its name still remains associated with the less fusible part of animal and vegetable fats, although this mixture is one of palmitin and stearin only; and since olein from the other series of glycerides is always associated with palmitin and stearin in these fats, we have the familiar name oleomargarin for this manufactured product; the same name could just as appropriately be given to many other fats, and just as incorrectly also; but it has come to be a trade name, the meaning of which is understood by everybody. First, when this oleomargarin, or oleo oil as it is sometimes called, is churned with milk and water, do we have the real artificial butter, or butterin.

The name of a Frenchman, Hyppolyte Mége, or Mége-Mouries, is most prominently associated with the early

history of this new food product. The statement is generally made that he was requested by the French government, and one writer says by Napoleon III himself, to make the experiments that led to his invention, for the express purpose of discovering a substitute for butter that would be cheap enough to come within the reach of the poorer classes and would also keep better than butter and thus be adapted for use in the navy. In 1873, he took out his first patent in this country, which was essentially as follows: The crude fat was first disintegrated between rollers, then heated about 103° F., to separate it from the tissues, or to *render* it, technically speaking; during this rendering, he added two litres of gastric juice for every 100 pounds of the fat; this gastric juice was obtained by macerating half of the stomach of a pig or a sheep with three litres of water containing thirty grammes of dicalcic phosphate; salt was also added to facilitate the separation from the tissue; the fat was then kept for a long time at a temperature of about 98° F., to allow the less fusible glycerides to crystallize out partially, after which they were separated from the more fusible part by heavy pressure in cloth bags; that which remained in the bags was called the stearin, and that which passed through the oleomargarin. This, the patentee says, is a fatty matter with a very good taste that may replace butter as used in the kitchen.

To make a more perfect butter, he mixes this first product, as it comes from the press, very thoroughly with ten per cent. of its weight of milk and cream and at a temperature of about 71° F. The mixture is cooled and worked between rollers to give it the consistency of natural butter. He has also found it expedient to mix with the milk or cream, one-fiftieth of its weight of mammary tissue from the udder of a cow, chopped very fine, one one-hundredth of sodium carbonate, and some coloring material.

This patent was followed by nearly fifty others, relating to the manufacture of oleomargarin, or some similar product, or artificial butter. Some of the new names introduced are curious; such as butteroid, oleoid, creamine, oxyline; this last name is very suggestive of the manufac-

ture of the substance from oxen. There are curious processes too in some of these patents as well as names; in one, the use of salt, saltpetre, borax, salicylic acid and benzoic acid is covered; in another, that of swine fat, cotton seed oil, slippery elm bark, and beef stearin; in another, nitric acid; in another, lard, beef suet, butter, glycerine, salt, water and coloring matter.

After all this effort of the inventors for something new in materials used or methods of manipulation followed, the process has simmered down to a very simple one, which is in reality only a part, and almost unchanged, of Mége's original process. The fat, said to be only the caul fat, and possibly so in all the large manufactories, is washed in cold water, surrounded with ice till the animal heat is removed, cut up fine, heated to from 120° to 150° F., allowed to stand till the fat is separated clearly from the tissue, then kept in wooden tanks for from twenty-four to thirty-six hours in a warm room, at such a temperature as will favor the crystallizing out of the largest part of the stearin, together with a little of the palmitin; then, in hydraulic presses in the same room, the solid fat is separated from the liquid, or the "oleo oil." Another product is prepared from lard in a similar manner, except that no stearin is removed from it, and this goes by the technical name of "neutral." From this oleo oil and neutral the oleomargarin and butterin are made, more oleo being put in if the product is to go to a cold climate, more neutral if to a warm one; the proper mixture of the two is churned in a steam-jacketed vessel, with about forty-eight gallons of milk to every 2,000 pounds of fat; it is stated that cream is sometimes used in the place of milk; butter coloring or annato is used unless forbidden by law. The churned product is suddenly cooled by allowing it to run out on to ice or cold water, then washed, salted and worked as butter usually is. The use of lard is comparatively recent, and it is interesting to notice that the first manufacturers of artificial butter were very indignant when it was attempted in the West to palm off a product from lard as oleomargarin; they used about the same contemptuous expressions concerning this

as the dairymen now use so freely when speaking of the oleomargarin. Such is the substance of the simple process for the manufacture of artificial butter in its various forms.

As to the quality of the product. In the first place, it keeps well if made from clean materials; because, as is claimed, of the absence of the lower glycerides of the series, especially butyrin, and also, as I think may be safely said, because more free from nitrogeneous matters in which the tendency to putrefy is very strong. A second important quality is such close resemblance to genuine butter of fair quality, that often only experts can distinguish one from the other. Amusing stories are told, illustrative of this close resemblance, many of them, perhaps, only partially true, yet all of them possible. It is claimed that samples of artificial butter have carried off prizes at fairs, for first-class genuine butter. One manufacturer certified before a legislative committee in my own State that he had in many instances put the artificial product before his friends by the side of dollar-a-pound butter or fifty-cent butter, and they were unable to detect the difference. I myself gave to a friend keeping an excellent boarding table, a small box of the artificial butter that I carried away with me from one of the manufactories in New York. The usual butter supply of this table was always unusually fine and the boarders were correspondingly critical; but they did not notice anything unusual in what was on the table at that meal. The story is told of a Board of Managers of the Agricultural Society of this State, that a print and a roll of oleomargarin butter were sent to them, with the inquiry "Which is butter;" at first they pronounced the roll to be butter; then they said the print was butter; then they tried some one of the simple tests that have been put forth from time to time for detecting oleomargarin, but which are usually worthless, and they finally concluded that both the print and the roll were oleomargarin, as they really were; but they closed their report with this question, "Are we right?"

But by far the most important question concerning the oleomargarin as food is that of its wholesomeness, as com-

pared with butter. The answer to this question turns on two points.

(1) The quality of the materials used in its manufacture.

(2) Its digestibility when properly made.

It may be safely said that no other food product has been so much discussed in respect to its healthfulness.

In the first place, what bearing has the quality of the materials used in the manufacture of oleomargarin on its wholesomeness? Concerning this, most damaging statements have been made; especially was this the case at the very beginning of the oleomargarin war. Many were doubtless suggested by some of the patents that were issued at this time; the purpose of some of these patents was openly stated to be to make foul fats clean, at least so far as taste and odor might serve to detect foulness. Here are a few of these statements, made or endorsed even in legislative halls. "All kinds of filthy fats are used." "Animals dying from all kinds of diseases are utilized." "Artificial butter is the compound of diseased hogs and dead dogs. It is so manufactured that it is a poison, for it has collected in it germs of all the diseases that infest animals." "The city scavenger butters your bread and his reeking hand decks your table." "St. Louis manufactures lardine, a compound of hog fat and decayed vegetable matter; horses dying with glanders or pneumonia, and dogs dying with rabies are carted to the boiling establishment where the fat is extracted and shipped away. What assurance have we that it does not find its way to the butterin factory? None." "This article of the slaughter pen and apothecary shop, the product from a charnel house run through a chemical laboratory, carrier of death and the grave." "A compounded article, mainly composed of ingredients that are not food products, or those of an inferior deleterious, and nauseating kind—refuse and offal which have served their purposes, and been relegated by the decent sense of mankind to the dung heap." The names of Congressmen making these statements are given in the document from which these extracts were made. A prominent agricultural writer of my own State wrote, "That there is nothing in the fat line

so filthy and disgusting that it cannot be deodorized and incorporated into the stuff." A Boston butter dealer stated, to the Congressional Committee, that "Every conceivable grease of the filthiest kind in our country is manufactured into imitation butter, and sold to consumers."

We all know that a good many things are said for effect by our legislators as well as by others that will not bear close examination into their correctness. If even the half of these statements were true, then certainly a committee of the New York Legislature, intent on making in its report the very worst possible showing against oleomargarin, in support of a very stringent and prohibitory law, could have obtained similar statements from some of the numerous witnesses cited before it; but a careful examination of the whole printed report of 276 pages, reveals no worse assertion than this, that not merely the caul fat, or that on the membrane investing the viscera, is used, but also that on the intestines themselves; and this witness affirms that this fat was in the vats mixed up with some of the excrementitious matters naturally associated with fat in that condition; but in the same report the manager of this factory testifies that not all of the fat received at the establishment is used for oleo, since they manufacture tallow also; and that but a very little of the intestines remains attached to that part of the fat used for oleo; the first witness did not testify that he actually saw the foul fat that he described worked into the oleo oil. No sound proof is anywhere given that such extravagant statements as those which I have quoted are founded on facts, or were anything more than conjectures or guesses.

But oleomargarin has been no less bitterly and extravagantly attacked on another line, namely, with reference to what has been found in it especially by microscopic examinations. Prof. Michels, of New York, in 1878, stated that he had found cells of a suspicious character, and fragments of muscle and tissue in some of the samples that he examined; these, however, he acknowledged came from the chopped stomach then used according to the original Mége patent; but he affirmed that trichinæ might get into the butter in

this way, and that the heat to which the fat was subjected in the course of the rendering and the crystallization would not be high enough to kill them.

In 1880, a Professor Piper gave in a Chicago daily paper some startling drawings of what he had seen in some samples of oleomargarin butter, under the microscope; shreds of animal tissues, spores, and a form often found by him in foul water; and in another paper he gave figures of actual tape-worm eggs, and by the side of these very similar forms from oleomargarin. Passing on to a later date, when the addition of chopped stomachs and mammary glands had been entirely given up, very little is reported of observations of this kind. A Professor Nachtrieb is quoted as finding in a sample of butterin parasites that are present in the rectum of swine, and in the evacution of patients suffering from chronic diarrhœa; but without further knowledge as to the reliability of this professor as a microscopist, one should give little weight to such a startling statement. Two samples of artificial butter out of ten were reported by an official of the Department of Agriculture as being full of fungi and their spores; but as all of these were also reported as being in a bad condition even for samples of butterin, such an observation furnishes no reliable evidence as to the usual quality of the substance; further, the reputation of this observer was not of the best.

Before leaving this part of my subject, I cannot forbear quoting one or two more of those wonderful Congressional statements: "The best samples had many kinds of living organisms in them, with masses of dead mould, bits of cellulose, various colored particles, shreds of hair, bristles, etc., while other samples teemed with life; doubtful portions of worms were also noticed." Again, "There were in every specmien more or less foreign substances, a variety of vegetable and animal life. Among these were corpuscles from a cockroach, small bits of claws, the blood corpuscles of sheep, the egg of a tape-worm, a portion of a worm, a dead hydra-viridis, portions of muscular fibre, fatty cells and eggs from some small parasite;" and all this, I am ashamed to say, said by a member from my own State. You

will notice that these two statements begin, the one with the words "the best specimens," the other with "every specimen." That any such observations could have been made on the best samples of oleomargarin, or even on all samples collected at any given time, is, I am safe in affirming, in the highest degree improbable, not to say entirely out of the question, even at the time when chopped pigs' stomachs and mammary glands were worked into the product; and that they could have been made, at or about the time when these statements were made, I consider quite impossible, such addition having been then long given up.

The answer to the question as to the wholesomeness of oleomargarin must then be sought on other lines of inquiry. Fats as such are not unwholesome when not eaten in excess. We need then only to consider whether one fat, clean oleomargarin, is as wholesome as another fat, butter, and we will consider first their comparative digestibility. By far the best statement of the case in this respect, it may be said, against oleomargarin, is to be found in the second annual report of the New York State Dairy Commissioner for the year 1885, by Dr. R. D. Clark, chemist of the commissioner. Many authorities are there quoted to the effect that butter is more digestible and wholesome than lard or other natural fats; and this difference is attributed to the more complex composition of the former, and especially to its butyrin. The effect of this substance is supposed to be due to the ease with which it breaks up into fatty acid and glycerin. Saponification is thus facilitated and the soap formed in its turn favors the digestion of the other fats of the butter. The digestion of the fats consists partly of this saponification, and partly of their conversion into an emulsion. Dr. Clark performed some emulsionizing experiments with different fats, and the pancreatic juice, which is the chief emulsionizing agent of the digestive liquids. Next to cod liver oil, butter gave the finest emulsion in twelve hours; while oleomargarin still had many large globules left unchanged. It is fair to suppose that the finer the emulsion and the more quickly it is made, the more readily the fat will be resorbed assimilated and taken into the circulation, and that easy

saponification will also favor digestion. Dr. Clark also proved that while butter melts to a clear limpid liquid in thirty-five minutes, at 100° F., the oleomargarin was but slightly changed; even after five hours the latter was still only in a semi-solid condition; this property of oleo butter is certainly not favorable to its digestion. Thus a very good case is made out by Dr. Clark, to the effect that oleomargarin is in all probability somewhat less digestible than butter. This view is supported by the results obtained by A. Mayer in a comparative test of the proportion of fat assimilated by a man and a boy, using butter of the ordinary kind for three days, and then oleomargarin for the same period; the difference was slightly in favor of the butter; but so slight that the writer considered that it might be neglected, except in the case of invalids or very young children. In France, the first opinion of medical men in 1872 as to the digestibility of oleomargarin was not unfavorable, but eight years later it was pronounced against in the Paris Academy of Medicine, the statement being that it could not replace good butter, because, on account of the higher percentage of fatty acids it emulsionized less easily and was therefore less easily absorbed; but I can find no account of any actual digesting experiments in support of this conclusion, like those of Mayer's just quoted, and which are of much more account than any theorizing.

The question of the occurrence of germs of disease in oleomargarin is of such great importance, that it needs some further consideration. The possibility of their occurrence there cannot be denied; and it must be allowed that the heat applied in any stage of the manufacture of the oleomargarin is not sufficient to kill these germs if present. Dr. Clark gives as diseases that may be communicated from animals to man, consumption, anthrax, trichinosis, tape worm, glanders, foot and mouth disease, cow pox, hydrophobia, etc.; the etc. implies that there are still others; but the list is fearful enough as it is. Now, what evidence is there that any of these disease germs are in oleomargarin? Granted that they may be there; but have they ever been found there by reliable observers? Any evidence

of this, sound and satisfactory, would be the most damaging that could possibly be produced against this food product. The observations, quoted in an earlier part of the lecture as made by Piper and Nachtrieb, utterly lack confirmation by others; no similar observations have ever been reported since. Dr. Clark, in his summary, does not even refer to them. It may therefore safely be affirmed that there is no evidence whatever that in the oleomargarin of later years, from 1885 up to the present time, any germs of disease exist.

But good evidence of the communication of any of these diseases to man by the use of oleomargarin would be no less fatal to this food product. Members of Congress assert that its consumption "Leads to insanity, Bright's disease and ailments that undermine the strongest constitution;" that "It is freighted with disease, freighted with death; that it spreads disease and death throughout the country." Dr. Clark, above quoted, in response to the demand for cases of illness caused by oleomargarin, can only say that "We have seen many cases of sickness, much of it dyspepsia, during the period in which bogus butter was so freely sold without restriction, for which we have been unable to assign any cause; this cause may have been the use of artificial butter; but the deceptive manner in which it has been handled has prevented physicians from ascertaining its effects; consequently we must judge by its qualities." This is a confession that up to that time, 1886, and only shortly after a time when it was claimed that 20,000,000 pounds per annum were made, and mostly used in New York and England, no case of disease nor any general specific form of disease could be pointed out as due even in the most indirect manner to the use of this food product. A widely quoted statement to the effect that the physicians of Chicago attributed the epidemic of winter cholera to the extended use of butterin in that city, into the composition of which lard entered largely, may be taken for what it is worth, as an exception to this statement of mine. I cannot verify or dispute it.

The chairman of the New York Legislative Committee,

from which emanated the present stringent prohibitory law of that State, in his report on the committee's investigations, could only say in reference to the wholesomeness of oleomargarin, that sickness of various kinds may result from its use, communicated by the germs of disease that have been found in samples of it; but nowhere in the report of the committee is any evidence adduced of the occurrence of these germs. Even a single case of disease unmistakably attributable to oleomargarin would have been invaluable in promoting the passage of the desired law; but he could not produce it; and in another place in the report he frankly allows that "There is evidence on both sides as to its wholesomeness; time and further investigation may be needed in order to establish a satisfactory solution of the question of trichinæ, animalcules or germs of disease in raw animal fats and their tissues. Meanwhile, however, there is well-grounded suspicion of them." Time there has been, years of it, since that report was made public. The prohibitory law was passed; but no further investigation has been reported on the trichinæ and germ question; and the danger of disease from this cause must be regarded as unproven.

An interesting incident bearing on this matter has very recently come to my knowledge. At an asylum for blind children, in Louisville, Ky., where good butter had been supplied, good oleomargarin butter was substituted. No notice was given of the change, and even if the appearance of the substitute would have betrayed it, the blind children could not have seen it. There was no evidence that they were in any way conscious of the change; but it was observed that they gradually ate less and less of the new butter and finally they declined it altogether. No bad effect on their health could be discerned. They made no complaint in answer to the inquiry as to the reason for not eating the butter other than that they did not care for it. It was as if it did not adapt itself to any need of the system. This certainly must be allowed to count against the complete fitness of oleomargarin as a substitute for butter.

Beyond what I have given you in what has gone before,

I find nothing more in the literature of this subject for the past twenty years that relates to the question of the danger to health in the use of oleomargarin, except numerous statements by scientific men of eminence in this and other countries. Morton, President of Stevens Institute; Chandler, of Columbia College, for so many years President of the New York City Board of Health; Johnson and Brewer of Yale, both well known by farmers throughout the country for the good work they have done in behalf of agriculture: Goessman, now and for many years past, Director of the Massachusetts Agricultural Experiment Station; Atwater, of Connecticut, so well known for his writings on food products; Armsby, Director of the Pennsylvania Experiment Station; Alvord, most prominently identified with the interests of farmers for many years, and now Director of the Maryland Experiment Station, all have spoken or written in favor of oleomargarin as a food product. It has required the courage of their convictions for many of these men to utter their opinions; and they have in many cases had only the comfort of a clear conscience to offset the abuse of the agricultural press that has been heaped upon them. Abroad, I would mention particularly Lyon Playfair, one of the most distinguished chemists and sanitary authorities of England. In his place as Member of Parliament, he spoke in a very different strain from that indulged in by some of our Congressmen, when he said, "As to the relative wholesomeness of oleomargarin and butter, I do not think there is anything to choose between them. Certainly, rancid oleomargarin is a nasty and unwholesome compound; but not any more so than nasty and rancid butter, which abounds in so many markets. Both are unfit for human food, although both may be purified by well-known processes." I would like to quote more from this admirable speech, but lack of time forbids.

Finally, allow me to call your attention to the remarkable absence of any reference to this food product, by the most active and efficient State Boards of Health in this country. If there were such terrible dangers lurking in oleomargarin, as has been so many times asserted, surely these Boards of

Health have seriously failed in the discharge of their duty in giving so little attention as they have to the matter. A careful examination of the files of such reports as are in our University library fails to disclose any allusions of any importance whatever to the subject. Some of these States have prohibitory laws, and their reports extend back from five to fifteen years.

The whole question of the wholesomeness of oleomargarin as food is summed up in my own mind about in this wise: When properly made from fresh and clean materials it differs but slightly in healthfulness from butter; and this difference is only on account of its somewhat less easy digestibility; that dyspepsia, which has been attributed to it, is likely to be due to a far greater extent to other causes than this, even among those who, because of its cheapness as compared with butter, would be likely to use it largely; that it is possible that it may be made from such unsuitable materials that it will contain germs of disease, and that disease might thus be communicated to man; but that there is no positive proof that it is now made of such materials, or ever has been, or that any disease has ever been communicated to man by its use; but that the possibility exists, all the same, and the only way to make it of no effect is by careful inspection of the process of manufacture by capable officials.

To my statement that probably no other food product has been so much discussed with reference to its wholesomeness, I may also add that none has been so much specially legislated upon as this. Let us consider what is the present condition of this legislation.

New York being a great dairy State, and also, in the beginning, the great centre of the manufacture of oleomargarin, was naturally one of the States in which special legislation began earliest. Two enactments in 1882 prohibited, (1) the coloring of the product to make it resemble butter, or the sale of any such colored product; and (2) required that all packages containing any such imitation of butter or cheese be plainly labelled. In 1884, the manufacture and sale of such imitation were forbidden in a

special section of a general dairy law. This was pronounced unconstitutional by the Court of Appeals; but another slightly different enactment in the following year was allowed to stand. The constitutionality of this final enactment was decided on this ground: that when a product of manufacture is turned out so closely resembling some other product of which the manufacture is already established, as not to be distinguishable from it by the senses, and is made for sale in the place of that substance, it is constitutional to prohibit the manufacture and sale of it. But if it is turned out in some different form, as, for instance, uncolored, then its manufacture and sale cannot be prohibited, except on plain grounds of injury to the health of the community. At the close of 1885, Maine, Michigan, Minnesota, Missouri, New Jersey, Pennsylvania and Wisconsin, besides New York, had laws prohibiting the manufacture and sale of oleomargarin or any kind of artificial butter made from other fats; and New Hampshire had a law that was practically prohibitory, requiring that all such imitation of butter should be colored pink. California, Colorado, Connecticut, Delaware, Ohio, Oregon, Rhode Island, Tennessee, Vermont and West Virginia had simply regulative laws, providing that the substance shall be sold under its own name.

At the close of the year ending June 30, 1891, Maryland had been added to the list of prohibitory States, and Minnesota, Vermont and West Virginia had joined company with New Hampshire in requiring the pink coloration of the artificial butter, while New Jersey, Massachusetts, and Ohio prohibited the sale of it only if colored in imitation of butter. Of the other States, Arkansas, Kentucky, North Carolina, Tennessee, Utah and Washington had no enactments in regard to the matter. The remainder of the States, twenty-five in number, merely required that it should be sold under its own name and not as genuine butter. Abroad the laws are all regulative, and not prohibitory.

In 1886, the national law was passed, under the title of "An act defining butter, also imposing a tax upon and regulating the manufacture, sale and importation of oleo-

margarin." This act required every manufacturer to pay $600 for a license fee; every wholesale dealer not a manufacturer, to pay a license fee of $480: and every retail dealer selling in quantities less than ten pounds, to pay a fee of $48; and that every pound sold shall pay a tax of two cents. It was first attempted to make this ten cents, but by reduction to the lower figure, the enactment was saved from being practically prohibitory. President Cleveland approved the measure on the ground that Congress is justified in making oleomargarin a subject of internal taxation; that Congress may clearly levy such taxes as will confer incidental advantages on the people; and that no industry is better entitled to such incidental advantages as may follow this legislation than our farming interests; and that the quality of the article will come under more strict scrutiny so that only a good and clean product will be sold; and, finally, the product will be sold under its own name and fraud and imposition will thereby be suppressed.

Recalling to mind some of the extravagant statements in Congress in support of this measure, or especially of the ten-cent clause of it, the comment on it as passed by a prominent agricultural paper is appropriate: "That if oleo is as bad as it has been painted, the new law will make the Government a party to the crime of permitting an unwholesome article and its action is, therefore, simply and purely a compromise with the devil." I wonder how many actually believed that it was as bad as it was painted?

What has been the motive in the passage of the sundry enactments concerning oleomargarin? Was it for the preservation of the public health, or for the preservation of another industry? The speech of the chairman of the committee, above referred to, in which the passage of a restrictive bill was asked for, covered twenty-eight pages of print of which only four refer to the public health. The great burden of the speech is the harm that is being done to the dairy interest by the secret trade in oleomargarin. Such statements as these are prominent. "A great and important industry of this commonwealth, and of the nation of which we are a part, is imperilled. The industry imperilled is th

American dairy." "The dairy to-day lies prostrate at the feet of this new butter king." Over against all this and more on this phase of the question, all that was said in the speech concerning the question of wholesomeness, was uncertain in tone, and wisely so, since so little proof could be adduced of the danger to health by its consumption.

In 1884, when the prohibitory bill was before the Senate, the burden of the argument for it was again the pecuniary loss caused to the dairy, of from $5,000,000 to $10,000,000 per annum; the sanitary side of the question was just touched upon, reference being specially made to the use of nitric acid in the rendering of the lard, which chemical, it was said, is a poison; but the committee could only state in general terms, an opinion that the oleomargarin is likely to be unwholesome.

In reference to the prohibitory law of Pennsylvania, the Supreme Court affirmed its constitutionality, saying that "The manufacture and keeping of an article may alike be prohibited by the legislature, if in their judgment the protection of the public from injury and fraud requires it." "The fact that the prohibited article may be innocuous is irrelevant; the sale of a mixture of pure water and milk has been prohibited." Here again the question of the public health is not taken into account. Of the same character was the decision of the Missouri Court of Appeals, on the constitutionality of the prohibitory law there; nothing was said about the public health. In the case of the almost frantic appeals sent out from Washington at the time that the practically prohibitory bill with the ten-cent clause was pending, it was the farmers of the country who were called upon to work upon their representatives directly, and upon the Senate through their respective legislatures, to secure the sufficient support of the bill in Congress.

So I might go on, adducing other evidence in support of my contention that the consideration of the public health has had very little weight in the minds of the ardent advocates of these prohibitory laws, or of any other legislation on oleomargarin, and that the money question was the real one at issue. Not a few protests have appeared from time

to time against such proscriptive legislation, even in the agricultural press. One of the most prominent dairy writers in the country, writing before the passage of these laws, said "There is no law and there can be no law to prevent its sale for what it is." Another, who, while he lived was esteemed as among the highest authorities in the country on dairying, when asked if the manufacture of oleomargarin should be prohibited by law, answered: "By no means. Its manufacture is as legitimate as that of butter. Its manufacture is actually a blessing. On the one hand it is suppressing the lower grades of butter; and on the other hand, it makes the finer brands of creamery butter more sought after. There is nothing for the dairymen to fear in it. Their safety can be insured by improving their butter product."

What has been the effect of this stringent legislation on the extent to which the product is manufactured, on its quality, and on the interests of the class of producers for whose benefit the laws have been enacted? It would naturally be expected that the first effect would be one of marked depression in the quantity made in some States, and of increase in others where no laws were made. It was stated in the New York Legislature by the chairman of the committee already many times referred to, that in 1888, 20,000,000 pounds were made in that State alone. This estimate is confessedly to a large extent guesswork. As to the total production in the country at any time previous to the passage of the national law, there appear to be no reliable data. It was wildly stated to be 200,000,000 pounds; it was admitted by those not interested in making the estimate excessively high, that the amount may have been half as great. For the fiscal year ending June 30, 1886, it was estimated on the basis of data claimed to be reasonably sound to be about 33,000,000 pounds. In the following year it was nearly 35,000,000 pounds; in the next year, 35,664,000 pounds. During the year ending June 30, 1891, 44,000,000 pounds were produced; and the great manufacturers, Armour & Co., of Chicago, predict a still larger output for the year ending June 30, 1892.

It is interesting to see where the manufacturers are, and also where the oleomargarin is consumed, the location of the retail dealers giving us very reliable information as to this last point. Concerning all of these matters the reports of the Commissioner of Internal Revenue furnish sufficient data. In 1889, there were twenty-three manufacturers, distributed as follows: Colorado, 1; Connecticut, 6; Illinois, 7; Indiana, 1; Kansas, 2; Maryland, 1; Massachusetts, 1; Ohio, 2; Pennsylvania, 2; the last-mentioned notwithstanding her prohibitory law. The other part of the story, about where it was eaten, is somewhat startling. Of the whole number of States, only eleven were not mentioned in the list of those having retail dealers within their borders. Of these eleven only three—Delaware, Maine and Minnesota—had prohibitory laws. As to the rest, beginning with the State having the largest number of retail dealers, Illinois had 1,091; Massachusetts, 460; Connecticut, 424; Michigan, 387; Ohio, 362; Missouri, 258; Pennsylvania, 157; Kentucky, 116; then follow the other States with numbers ranging from eighty-five down to one. Two bold firms even dared to open shops for the sale of oleomargarin in my own State, in 1887, another was added in 1888, and all three were there in 1889.

But what shall be said of the condition of the matter in some of the other States with prohibitory laws? Missouri was the first to have such a law, and even you Philadelphians had in that year twenty-five dealers in your very midst, and 157 in the whole State; and you have a prohibitory law, too, that your courts have pronounced constitutional. Michigan, with her prohibitory law, also had 387 retailers of "the vile stuff," as our Dairy Commissioners are accustomed to call it; Wisconsin, another prohibitory State, had 85 dealers, and New Jersey, still another, had 75. As for New Hampshire, her 47 retail dealers who have been in operation since 1887 had probably learned how to color their oleomargarin butter such a delicate pink that it would not be noticed by the unsuspecting boarder, but still enough to comply with the law; or do they come out in bold defiance of a very natural preju-

dice against pink butter, and color it deeper than ever the brightest carnation showed.

Another interesting feature of the statistics given in the Commissioners' reports is the steady increase in the total number of retail dealers, from 2,316 in 1887–88, to 5,914 in 1890–91. In Missouri, the number increased to 627, or more than double what it was in 1889. In Pennsylvania, the number had risen to 1,100, and there were, besides, 2 manufacturers and 59 wholesale dealers. Only four States paid, in 1890–91, a larger share of the revenue on oleomargarin collected by the Government than did Pennsylvania; those States being Connecticut, Illinois, Kansas and Ohio; of this $46,000 was paid at Pittsburgh.

In New York the law is well enforced with the aid of a large appropriation and many officials. All the usual channels by which this oleomargarin is liable to enter the State are carefully watched and a few convictions are made each year. One of the discoveries thus made in 1890 was on a small island in Long Island Sound, where "the vile stuff" was found in a room used mostly for storage of rubbish—300 pounds of it packed in the bottom of an old ice chest, covered several layers deep with potato bags, and then the box itself covered with bags and old boxes. The proprietor was arrested, pleaded guilty and was fined $100.

These figures as to the consumption of this food product in the country, seem to indicate that there was not a hearty public sentiment behind the noisy clamor that urged many of these enactments on to their passage. This view of the matter is strengthened by the fact that so few of the more influential agricultural papers, and of the best writers for these papers were in favor of prohibition; at least such was the case in my own State; and it is only reasonable to suppose that they voiced the feeling of the majority of the farmers for whose supposed benefit this commotion was raised. What the best part of the press and the most intelligent part of the farmers wanted was simply a law requiring that these oleomargarin productions should be sold under their proper names; that there should be no cheating or deception, but that everything about this new business

should be open and above board. Then they would have nothing to fear from it.

As to the quality of the product now, as compared with what it was in the first years, such a comparison cannot be made with any degree of satisfaction, since we have so few reliable data, based on official inspection of the manufacture or of the product. President Cleveland gave this as one reason for his approval of the national law, that the quality of the article will come under more strict scrutiny, so that only a good and clean product will be sold. But it cannot be said that this hope is justified. In the first report of the Commissioner under the new law, the inspectors in some cases stated that they had examined into the character of the materials used at the factory, and they found everything as it should be. But since that time I find no evidence in any of the reports that any attention is given to this matter by these inspectors.

As to the effect of the legislation on oleomargarin on the the butter product, it is also very difficult to reach any satisfactory conclusion. Many assertions have been made as to the depression in prices of butter caused by the introduction of oleomargarin, and *vice versa;* but there are very few carefully prepared figures in support of this assertion. On the other hand, in 1882, a comparison was made between the prices of butter in January and July, for the five years from 1857 to 1861, inclusive, before the war, with those of the corresponding months of 1877 to 1881, inclusive, when oleomargarin was actively made and sold; the average price was three cents a pound higher in the latter period for the best butter; and in the last two years of each period, it was seven to eight cents higher, with oleo sold under very little restriction. This statement was published in that stanch agricultural paper, the *Rural New Yorker*, and commented upon as indicating little benefit to dairymen from the prohibitory law. Elgin, Ill., is claimed to be the headquarters of the finest creamery butter, selling at forty to sixty cents a pound to the consumer. In January and February, 1886, the wholesale price of butter at the factory was nearly two to five cents a pound higher than it

was in January and February, 1887; that is, a few months after the law went into effect, butter fell in price instead of rising, much to the chagrin of some speculators who bought largely for a rise.

The New York Dairy Commissioner, in his report for 1887, claims that the enforcement of the law in that State has encouraged dairymen to feed better, and produce a larger amount of butter, for which a higher wholesale price has been paid, while consumers have had to pay but little if any more, and from his figures he estimates that the net gain to the dairy producers in the United States during the two years ending November 30, 1887, was $40,000,000.

These and other statements indicating large gains for the dairy industry by the suppression or restriction of the manufacture of oleomargarin, do not seem to be borne out by the following table, taken mostly from the report of the Commissioner above-mentioned for 1889, representing the receipts and value of butter handled in New York City for nine years:

| Year. | Total Amount. | Total Value. | Price Realized. |
|---|---|---|---|
| | *pounds.* | | *cents per pound.* |
| 1881–2 | 79,864,840 | $23,025,295 | 29 |
| 1882–3 | 90,547,910 | 22,627,579 | 24 |
| 1883–4 | 88,117,170 | 20,342,372 | 23+ |
| 1884–5 | 93,566,850 | 19,502 977 | 21— |
| 1885–6 | 93,701,520 | 20,925,537 | 22+ |
| 1886–7 | 93,712,480 | 21,357.988 | 23— |
| 1887–8 | 95,242,360 | 22,065,219 | 23+ |
| 1888–9 | 108,477,260 | 23,386,456 | 21·5 |
| 1889–90 | 97,655,160 | 18,109,142 | 18·5 |

The net gain to producers whose butter was handled in New York City in the two years ending November 30, 1887, was $1,859,011; whether it is safe to estimate from this that the gain over the whole country for that period was $40,000,000 I leave for others to judge. The heavy fall in the prices realized for butter in the last two years of the seven, shows

that other causes affect this price besides competition with oleomargarin; the unsoundness of conclusions based on one set of statistics alone of the trade in one city should also be taken into account.

But the butter industry is threatened in other ways. A German chemist has found means to purify fat obtained from some tropical plants in such a way that it will keep well and can be made into an imitation of butter. A company has been formed in the Netherlands for the manufacture of this butter; and the editor of a prominent journal established for the purpose of exposing adulterations of food, called for the preparations of several articles for the table with this butter—he being a member of one of the juries of the exposition where this butter was shown. The universal judgment was that it was excellent, and should bring the highest price. The editor of the paper from which this is taken, says that one must keep a watchful eye upon this new industry in order that at least this vegetable butter cannot be used for the adulteration of genuine butter.

Further, the attention of the Department of Agriculture has very recently been called to a more serious mode of adulterating butter than by the use of either oleomargarin or the vegetable butter. A substance, called "gilt-edge butter compound" was received indirectly from the Planet Manufacturing Company, Wichita, Kan., with the statement that by taking equal parts by weight of genuine butter and of milk, or one pint of fresh milk and one pint of butter, and one gramme of this compound, two pounds of butter can be obtained. The process consists simply in making the genuine butter first somewhat soft and pliable by warming and working it so that the churn dasher will go through it, and then churning the whole together, the milk being warmed to about 100° F., and the churn scalded so as to warm that; then salt and butter color are added. The direction is given not to work the product, but to put it away into jars in a cool place to harden. On analysis it was found that the genuine butter contained about sixteen per cent. of water, while the sample of the counterfeit

butter made with this genuine butter and with milk and the gilt edge butter compound, contained almost fifty per cent. of water. It was learned on examination that this gilt-edge butter compound contained pepsin; and experiments that were made showed that this ferment gives to butter, by acting as an emulsifying agent, the property of taking up much additional water and that the rennet ferment will act in the same way. The whole process is a very inexpensive one for loading the genuine butter with a large additional quantity of water.

As a chemist, it may be expected of me to say something about the means of detecting oleomargarin in genuine butter. A complete study of the various methods for this detection occupies many lecture hours in the course to my students in chemical analysis. Very brief treatment of the subject must, therefore, suffice here. It was shown in the beginning of my lecture that the change in the properties of the fatty acids and their compounds, as we pass from one member of the series to another, is very slight; and that it is only when we compare members of the series that are widely apart that we have such wide differences as to enable us to distinguish or separate them readily—differences in the melting point, solubility, or volatility. The fact that the fat of milk contains glycerides of two groups of fatty acids, thus widely enough separated from each other to give us marked differences in solubility and volatility, comes to our aid in distinguishing the butter from nearly all other fats, both animal and vegetable; it is the one quality of butter that enables us to make use of chemical analysis in the detection of the adulteration of butter with other fats. Butyric acid and its three associates in butter are soluble in water and can be distilled without decomposition; palmitic, stearic and oleic acids are quite insoluble in water, and are completely broken up if we attempt to distil them. Therefore, we have only to get the fatty acids out of the glycerides by saponification and decomposition of the soap by a mineral acid, treat this mixture of the fatty acids with boiling water, and separate the soluble part from the insoluble by filtration, and dry and weigh what is on the filter. The

highest per cent. of these insoluble acids that is allowed to exist in genuine butter fats, on the basis of a large number of determinations that have been made, is ninety; in oleo oil, tallow, lard, cotton-seed oil, we have from ninety-three per cent. and upwards. When butyric acid and its associates are separated out by distillation in the manner already explained, we can estimate their amount by measuring the acidity in the distillate collected; this measurement being now always expressed in the number of cubic centimetres of a one-fifth normal solution of sodium hydroxide that is required to neutralize the volatile acids obtained from two and one-half or from five cubic centimetres of butter fat. This number, which we may call the Reichert number, after the name of the chemist who discovered the method, ranges for genuine butter from ten upwards for two and one-half grammes of butter fat, or twenty upwards for five grammes of fat. The highest number for oleo oil, lard or tallow is less than one, and for cotton-seed oil and cocoanut oil seven.

By these means there is not the slightest difficulty in distinguishing pure butter from pure oleo oil, or the other preparations of a similar character; nor is it difficult to distinguish butter adulterated with, perhaps, fifty per cent. of oleo oil and upwards, but the results are not sufficiently positive for adulteration with lower amounts. Furthermore since some animal oils that can be procured in quantity have been found to contain so large a proportion of these glycerides yielding volatile fatty acids, that by the addition of them to oleo oil, the Reichert number can be brought up to that for genuine butter, with little difficulty, our dependence on either of these two methods for detecting the adulteration may yet be made very insecure. For instance, porpoise jaw oil has been found to yield a fatty acid mixture by saponification, and so on, of which the Reichert number ranges from forty-six to sixty-six; it needs only that this oil shall be so refined as to deprive it of its fishy taste and odor, in order that it may be used to put chemists entirely off the scent, in the use of their analytical methods for the detection of adulteration with oleomargarin.

A multitude of simple tests have been proposed from time to time, and of such a very simple character that any one can make them with the simplest of appliances; but they have little value, being usually quite unreliable, and no conviction could ever be based on any one of them, or on all of them combined. One of these, simple in execution, though not in appliances, since it requires the use of a good microscope, depends on the fact that when a fat solidifies from a state of fusion, crystals are formed which, viewed by polarized light under the microscope, show a distinct play of colors or other very characteristic appearances. The process of manufacture of oleo oil in any of its forms involves in all cases the melting of the fat. Butter, unless exposed to unusual heat is never melted; hence, normal butter will never present this phenomenon under the microscope with polarized light, while any fat refined by the application of heat, at any time during the process of its manufacture into imitation butter, will always show it. This simple method has been severely criticised; for it has been shown that under some rarely occurring circumstances oleomargarin may possibly not exhibit the phenomenon, and that butter although perfectly genuine may have been sometime just enough warmed to be partially melted, and then it will exhibit the phenomenon described. Nevertheless this test can be and is used by the inspectors of the Internal Revenue Bureau, specially adapted microscopes being supplied to them; but it serves only to indicate suspicious cases; a sample thus indicated as suspicious is subjected to analysis before any action is taken concerning it.

To sum up what appears to me the fair position in regard to oleomargarin: It is a food product unquestionably. No legislation can rule it out of the list of food products. Taken into the system it follows the same course that butter does, is changed in the same way, if not perhaps quite so completely; is taken into the circulation, and then serves precisely the same purpose that butter does. When properly made from proper materials it is entirely harmless, except possibly when consumed as freely as butter would be by persons with weak digestive powers.

While it is claimed by manufacturers that a good artificial butter cannot be made, if fats are used that are not clean and wholesome at the start, it may not be that this is fully established. But on the other hand, it must be granted that there is no evidence that any community in which artificial butter has been used, even freely and without any official inspection or restriction, has been any the worse for its use in respect of health, either individually or collectively. These being the facts in the case it is not surprising that many regard as unjust any legislation that prohibits the manufacture or sale of this substance, whether directly, or by such ridiculous subterfuges as require it to be colored pink or any other abnormal color; the chief motive, nay almost the only real motive for this legislation being that of attempting to save another industry, working along the same line, from pecuniary damage.

On the other hand, oleomargarin is not butter; and it is wrong to sell it as butter, no matter how good the imitation may be. Probably its manufacturers and dealers have brought all this trouble on themselves in the way of prohibitive legislation, by their attempts to sell it as butter; if from the first it had been sold under its own name, I very much doubt whether any prohibitory law would have been enacted in any State. All over the civilized world, general or special laws exist, prohibiting the selling of anything for what it is not; no one denies the need or equity of these laws; their purpose is to protect honesty against dishonesty, and to give every honest man a fair chance, whether he be a seller or a buyer. When a man sells oleomargarin as butter he is violating these laws; and in proportion to the ease with which the imitation can be palmed off for what it is not, and in proportion to the value of other industries that are injured by such deceit, should be the efficiency of the means for the detection of the fraud and the severity of the penalties imposed upon it; so that the producer of the genuine article shall not need to go far out of his way for the means of defence. Therefore, laws requiring that oleomargarin shall be sold for what it is are just laws, I care not how stringent they may be.

Furthermore, there is work for Boards of Health in connection with the trade in this food product wherever it is permitted; especially should its manufacture be watched. This needs to be done at least till it has been fully established that only clean fats from animals killed in health can be used for its manufacture. The large license fee required of manufacturers throws the manufacture into comparatively few hands, and such inspection is thus rendered comparatively easy.

Under such restrictions it seems to me that the trade in this article might safely be left to itself, and that it might be a blessing to the community as a whole, in supplying at low prices a savory substitute for butter, far better in quality than most of that which the poorer classes have to eat, if they can get only genuine butter; and for those who can afford to pay for good butter, the opportunity to get it will be better, for dairymen will be obliged to make good butter if they make it at all.

## PRECISION IN THE USE OF THE TUNING-FORK CHRONOGRAPH.

By Walter L. Webb, C.E.

During the course of some recent experiments (in the laboratory of the College of Civil Engineering at Cornell University), in which it was necessary to determine very precisely an interval of time of about 0·72 seconds, an ordinary tuning-fork chronograph was at first used, with a cylinder of smoked paper and a tuning-fork vibrating (approximately) 100 times per second. The cylinder was turned about one-fourth inch for each vibration. The fraction of a vibration at each end of the interval was then estimated as nearly as possible to tenths of a vibration, and this gave the total time with an error perhaps not more than ·002 second. But even this error was inadmissible for the purposes of the experiment. Moreover, the smoked paper was untidy and inconvenient, and the tracings of the stylus were sometimes spoiled by accidental rubbing, even

in spite of great care in handling. And so another method was devised which gave on one set of six observations a probable error for the mean, deduced by least squares, of ·000088 second. And this did not require a larger or more costly chronograph. It needed but a few changes, made by the writer, in the ordinary chronograph that had been previously used. The first change was the substitution of white paper for smoked paper, and of pens for the styluses. The paper used was very smooth and white, but with no glaze, which enabled it to take ink freely. With a slow motion of the pen it takes ink too freely; the rapid motion here used being just right. The pens were made of very thin sheet brass rolled into conical tubes: the marking ends were filed until they would make a fine mark on the paper. The cones would hold more than enough ink for a single observation, and the tubular form prevented the spattering that would inevitably have occurred with an open pen, vibrating 100 times per second, with an amplitude of, perhaps, one-fourth inch, and containing enough ink for a line several feet long. Using ink rather than smoked paper, the paper could be handled freely without injury. And that made more easily possible the other change of method, viz: the determination of the fractions of vibrations at each end of the interval by means of the microscopes and screw of a dividing engine.

The absolute equality of the intervals of time for the different observations depended on the time required for a small body to drop a fixed height through a vertical shaft about nine feet high, made sufficiently air-tight to avoid the effect of outside currents of air, and in which the pressure, temperature and moisture were carefully determined. The beginning and end of the interval were *both* indicated by the breaking of an electric circuit and by precisely the same motion of the recording armature. Any irregularity in the action of the armature would probably happen at the end as well as at the beginning of the interval, but if there actually was any difference, it was instantly discernible by the comparative forms of the curves described by the pen of the recording armature as

it flew back on the releasing of the current. The time required for the armature to fly back was generally about ·005 second. Every precaution was taken to make every circumstance, affecting the recording of the beginning of an interval, have an equal weight and influence in the recording of the end of that interval, so that all errors were either eliminated altogether or made mutually compensating.

In the accompanying specimen of the actual work done by this process, the right hand line is the line drawn by the pen on the recording armature; where it is crossed by *c d* is the tangent point of the curve immediately below it, and shows when the current was broken and when the armature began to fly back. The paper was placed on the carriage of the dividing engine, so that the line made by the recording armature was parallel to the line of motion of the carriage. The microscope on the dividing engine magnifies about twenty-four diameters. That would cause the distance from line *a b* to line *e f* to appear as about six inches. Thus it was very easy to move the carriage until the middle cross hair in the microscope was directly over the crest of the wave as at *a b*. The reading of the screw was then taken. By moving the carriage until the tangent point (on *c d*) and the next wave crest (on *e f*) were successively under the cross hair of the microscope, the ratio of the differences of the readings easily gave the value of the partial vibration. The screw pitch is one millimetre, and there are 200 divisions on the circumference of the wheel attached to the screw. This gives about 1,250 divisions for a wave length of one-fourth inch, and so it need not be considered an unwarranted refinement to compute the ratio to the nearest hundredth. For example:

| | | | |
|---|---|---|---|
| 119, 458, 1460, .... | ·25 | ... 0·25 | |
| 158, 859, 1155, .... | ·70 | ... 72·70 | .... 72·45 |

This is computed as follows:

$$\frac{458 - 119}{1460 - 119} = \frac{339}{1341} = .25 +$$

and similarly for the other fraction of a vibration.

If, under the microscope, there seemed to be any uncertainty as to the exact position of the tangent point (on *c d*) or of the wave crests, the observation was either rejected altogether or was weighted according to judgment. But, as shown below, an observation weighted low has not in general the greatest variation from the accepted mean of the series.

The values obtained on a series of twelve observations were 72·53, 72·59, 72·57, 72·53, 72·35, 72·44, 72·41, 72·57, 72·48, 72·31, 72·56, 72·50. The first and ninth were given a weight of 1 on account of uncertainties in their determination, and all the others a weight of 2, but the ninth very nearly equals the finally accepted mean, and the first has not as much variation as many others. The mean thus computed is 72·487 vibrations. The rating of the fork was determined by means of a series of observations with a standard clock to be 100·471 vibrations per mean second. The mean time, therefore, equals ·72147 second. The probable error for the mean of this set was found to be ·00018 second.

After experimenting with forks with higher rates, it was decided that a fork vibrating 100 times per second was the best. With 1,000 vibrations per second, the vibrations have but little amplitude, and it would be difficult to do more than count the whole number of vibrations with certainty. With the fork used, it is comparatively easy to produce and maintain an amplitude of one-eighth inch to one-quarter inch for the whole observation. Then, when the cylinder is turned about one-quarter inch for each vibration, a curve is produced on which the crests are very definite. In fact, the greatest uncertainty in the determination is generally in locating the exact position of the point of curvature on the line traced by the recording armature, and since this point is better defined when the cylinder is revolving more slowly, it becomes all the more necessary that the vibrations per

second should not be so increased that the speed of the cylinder must be increased in order to render the vibrations distinguishable.

Of course, the accuracy of this method depends on the uniformity of the rotation of the cylinder during the vibration considered, but the probable change in the velocity of rotation of the heavy cylinder during ·01 second is evidently so small that its effect on these computations would be inappreciable.

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## PHYSICAL EXERCISE IN HEALTH AND AS A REMEDY.

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[*A lecture delivered before the Franklin Institute, December 7, 1891.*]

The human body is usually assumed to be fairly symmetrical as to its parts and healthy in its organic workings. This is more nearly true now perhaps than a century or two gone by, and in certain communities, but is far from true of other localities and earlier times. There are conspicuous instances in history of peoples among whom for long periods a very high standard of physical perfection prevailed. It may be remarked that along with this was observed also a large measure of intellectual vigor. If among the young of our own families and friends, search be made to-day, there will be disclosed a pitiably large number of defective organizations, needing judicious care to develop into normal men and women. If this assertion should be challenged, little demonstration would be needed to make the matter clear. Further, invaluable records are now growing which leave no reasonable ground for doubt, as I shall show anon. (*Sargent's Normal Man*, etc.)

These instances of "half-built boys," as Blaikie calls them, will be obvious to a critical observer in any gathering of youth.

I claim it is the plain duty of all medical men and teachers to recognize such cases and provide remedies within their jurisdiction and powers. The child being father of the man, and he again of other men so long as the race survives, it should be the blessed prerogative of the physician to stamp out insidious seeds of disease, to enhance the vital forces of the men to be, by aiding to equip the child with all potentialities his present heritage and domestic plane can be made to furnish. We can and should help the growing bread-winner to sharpen his capacities and broaden his powers, not only in one but remote generations.

Medical art and science is but the common-sense presentment of vital laws applied to keep the body whole. When wrecks have occurred we must work night and day to get these again afloat, patch up the leaks if possible, and restore to such normal plane as may be. Our best prerogative, however, is to act as pilot, and, armed with authority, warn vessels off shoals. More than this, we strive to act in prophetic capacity, foretelling the weather and dangers that lie far hence; how human ships may be more wisely constructed, more speedily and economically run, and, in short, exert a vigilance that may tend to save and expedite the mortal crafts that sail on treacherous seas.

First, then, let us give more and increasing attention to conserving, and increasing to the uttermost the forces of our boys and girls; next in importance, and of less promise in possibilities point out to adult folk how they may maintain and add to their working powers. Lastly, we will consider the remedial power of simple exercises in re-establishing the lowered health.

The first instinctive movements of a healthy child are rhythmical and graceful, though of most limited scope. If not hampered, as too often happens, by inappropriate clothing, these will rapidly improve in power and coördinative range till the full measure of his inherent capabilities be reached. Given continued health, ample space and energy enough in any reasonable climate, and children will develop into wholesome men, competent to do their duty in whatsoever range that may lie. Let these fair conditions

be absent in whatever degree and infinite skill and pains are needed to save and shape the inherent power.

Practically, it is always needful to husband and wisely conserve growing forces.

*Health.*—Health has been briefly defined as a "balance betwixt the various parts of the organism in power as well as in function."

A hasty review of these processes may be useful to make clear the deductions further on.

Life in its simplest acceptation involves the idea of constant change. We do not consider a being as alive which is not undergoing some continual alteration, however slow and obscure. This alteration may be evidenced by the growth and extension of the organic structure, or by molecular changes in its substance which do not produce any ostensible increase; or it may be most obviously manifested in movements such as cannot be attributed to any physical cause. The life of any complex organism, such as that of a man, is, in fact, the aggregate of vital activities of all its component parts. In every living structure of complex nature, whilst we witness a great variety of actions resulting from the exercise of the different powers of its several component parts, we at the same time perceive that there is a certain harmony or coördination among them all, whereby they are made to concur in the maintenance of the life of the organism as a whole. If we take a general survey of these with reference to their mutual relationships, we shall perceive that they may be associated into groups, each consisting of a set of actions which, though differing among themselves, concur in effecting some positive and determinate purpose. These groups are termed functions.

The exercise of the animal function is essentially destructive of these instruments; every operation of the nervous and muscular systems involves as a necessary condition, a disintegration of a certain part of their tissues; so that the duration of the existence of those tissues varies inversely to the use that is made of them, being less as their functional activity is greater.

A compensating operation of the constructive function is

therefore required in order to repair the loss of substance thus occasioned; from which it happens that the demand for nutrition, and therefore the necessity for food, is in great degree regulated by the functional activity of the nerve-muscular apparatus. We are not, however, to measure the activity of the nervous system, like that of the muscular, only by that of movement to which it gives origin. For there is equal evidence that the demand for blood in the brain, the amount of nutrition it receives and the degree of disintegration it undergoes, are proportional, likewise, to the energy of purely psychical operations, so that the vigorous exercise of the intellectual powers, or a long-continued state of agitation of the feelings, produces as great "waste" of nervous matter as is occasioned by active bodily exercise.

The functions, therefore, of the animal body are so completely bound up together that none can be suspended without cessation of the rest. The properties of all the tissues and organs are dependent upon their regular nutrition by a due supply of perfectly elaborated blood. This cannot be effected unless the functions of circulation, respiration and excretion be performed with regularity, the first by necessity to distribute the supply of nutritious fluid, the second being requisite for its oxygenation, and also needed in conjunction with the third, to free it from impurities which it contracts during its circuit. The respiration cannot be maintained without the integrity of a certain part of the nervo-muscular apparatus; and the due action of this again, is dependent not only upon its regular nutrition, but also upon its supply of oxygen. The materials necessary for the replacement of those which are continually being separated from the blood can only be derived through the absorption of ingested aliment, and this cannot be accomplished without the preliminary process of digestion. In order that an organized fabric may be maintained, it is obviously needful that there should be a ceaseless supply of needed particles; that these, when certain elements have been used up, be replaced by others. Again, if the processes of waste and decay be not compensated by renewals, there results starvation or exhaustion.

During the whole period of growth there is ceaseless remodelling of the whole structure, the life of each part being brief to enable its renewal on a different scale. Children, therefore, require more food in proportion to their bulk. Old persons, in whom the ebb and flow of vital activities are sluggish, where waste and repair are retarded, need less. The production of heat needs extra food to maintain the temperature of the body in varying atmospheres.

During great activities and in cold atmospheres much food is demanded, the more readily combustible with least waste, the better.

Digestion prepares the nutritive materials to be thus conveyed to the tissues. These undergo important changes in their progress toward the centre of the system till they become pure blood. This is the true vital fluid, which reconstructs the tissues, and gathering up the waste of the circulation, submits itself to the bath of oxygen in the lungs, where it is again made fit to start on its life-giving course.

The propulsion of the flood through the large vessels which subsequently divide into capillaries, is due to the contraction of a hollow muscular organ—the heart. These, like the pulsating movements of the alimentary canal, are largely independent of the agency of the nervous system. The rate and force of these vascular movements are greatly influenced by states of nervous energy, thereby calling into play the contractility of the arterial walls, exert a powerful effect upon their calibre, and consequently on their distribution of blood to particular parts and organs.

The steady disintegration which incessantly occurs in living tissues, renders it imperative that efficient means be provided for conveying away waste. This is almost as important as that new material should be supplied, and is especially to be emphasized in connection with the subject of muscular exercises. The venous system takes away a large part of the products of incipient decomposition, and transfers these to the organs of excretion, by which they may be seperated from and cast out of the body. The first product of the decay of all organized structures is carbonic

acid; and this is the one which is most constantly and rapidly accumulating in the system, and the retention of which in the body is the most injurious.

Accordingly we find a most important set of organs, the respiratory apparatus, adapted to this end. Through this the whole current of the venous blood passes before it is again sent about the system. Here, spread out upon the meshes of the lungs, it is exposed to the atmospheric air whereby the carbon dioxide is removed and replaced by oxygen, in accordance with the physical law of the diffusion of gases. The introduction of oxygen into the blood is peculiarly essential for the maintenance of those vivifying powers by which the nervous and muscular systems are kept in a state of normal balance. The demand for oxygen and excretion of carbonic acid vary according to the amount of nervo-muscular action put forth. The continual formation of carbonic acid in this and other interstitial changes, has a most important purpose in the vital economy—that of keeping its temperature at a fixed standard.

The function of the greatest excreting organ of the body—the liver—is like that of the lungs, twofold; it separates a large quantity of superfluous hydrocarbon from the blood which this acquires while circulating through the tissues, and it combines this with other elements into a secretion which is of the greatest importance in the digestive process.

But further, all animal substances have a tendency during their decomposition to throw off nitrogen as well as carbon, and this nitrogen in combination with other elements forms those peculiar azotized compounds which it is the special duty of the kidneys to eliminate from the circulating fluid. The most characteristic in man is urea. This contains a larger proportion of nitrogen than is found in any other organic compound.

The action of the kidneys, which also serve as emunctories for various soluble matters, especially saline, is equally essential to the other vital functions with that of the lungs and liver. The regulation of the amount of fluid in the vessels is provided by a kind of safety-valve structure in

the kidneys, which allows the escape of watery fluids from the capillary vessels into the urinary canals by transudation. This is quite distinct from the secretion of that solid matter which it is the special office of the kidney to separate from the blood. Hence, if the excretion of the fluid from the skin be checked by cold, the increased pressure in the vessels causes greater escape of water through the kidneys.

All digestion, as Fothergill picturesquely describes it, "is a process of solution by hydration." Hence, if the ingested water be not sufficient, not only does digestion suffer, but all the secretory organs fail. One of the first and most conspicuous advantages of bodily exertions is, to demand by thirst an ample measure of this invaluable solvent.

*Effects of Exercise; Phenomena of Muscular Action.*— During the process of muscular contraction there is put forth the power of converting latent energy into muscular force. This property is inherent in the muscle, and is controlled by nervous discharges. Little is known of this mysterious influence of nervous energy other than that it travels as a wave of molecular disturbance along the nerves to thin, terminal expansions in the muscular fibres. On its arrival there it is converted into muscle impulse. Along with this certain electrical phenomena are manifested. These contractile movements are accompanied by molecular vibrations, which give rise to a distinct humming sound. In damaged muscle, as in palsies, the normal pitch of this musical note is lowered, the number of vibrations being lessened. The normal temperature falls slightly at the beginning of the contraction, but often rises above that in quiescent states, and continues to increase for a time after the cessation of activity. The flow of blood is increased during voluntary contraction as the capillary vessels in muscle run between the elementary fibres. The amount of blood supply, and in consequence the capacity for prolonged. work, must vary for the same bulk of muscle in proportion to the smallness of the fibres. In women these fibres are of smaller size than in men, and Haughton claims to have found by direct experiment that "the muscles of women

are capable of longer-continued work than those of men, though inferior to them in force exerted for a short time." Important chemical changes take place in muscle during contraction, but our knowledge of these is not yet clear. The muscle substance becomes distinctly acid then, whereas in repose it is neutral, and the splitting up of organic molecules becomes active, throwing off carbon dioxide and urea. Respiration is increased most markedly during exercises in which the whole body partakes. A careful estimate made by Dr. Edward Smith shows that the quantity of air inspired varied from one, in a sitting posture, thence through a series of acts, such as standing, walking, slowly riding, and finally walking and riding rapidly, carrying weights, etc., until at last while running six miles an hour, the unit is multiplied nearly seven times. The elimination of carbonic acid from the lungs, he estimated carefully with similar results. During the most moderate exercise, the increase in force and frequency of the heart beat is very great and sudden. The vessels dilate, the blood stream is rushed swiftly through the body, and particularly to the muscles where required.

*General Effects of Exercise.*—To get a right estimate of the effects of muscular work on an adult person of normal nutrition, it would probably be more instructive to begin by considering the results of insufficient exercise. Here, the nutritive processes continuing in healthful activity, there comes a state of over-nutrition, or undue piling up of assimilated matter. This process can continue without disturbance for a very considerable length of time, and until a greatly increased and exuberant state of nutrition results. Thus persons who have a tendency to become fat accumulate vast masses of fat on their surfaces where it is safe enough. Unfortunately, this may go on until the deeper structures are infiltrated, which constitutes a diseased process. A certain amount of this reserve fat is of use, upon which the vital forces may draw at need. Again, this has its value for those who are exposed to low degrees of cold; and, further, if one should fall into a fever, a fair amount of fat enables him to run a long time without the need for

other than the smallest amounts of new food. There are many discomforts, of course, which are produced by this large addition to one's weight which makes it worth the while of those so discommoded to seek for it a remedy. Again, in those whose nutrition is not so good, there comes about a lowered state of vital forces due to an insufficient admission of oxygen into their tissues. All the organic processes become impaired if the normal amount of oxygen be not supplied. A torpor grows not only upon the muscular movements, but upon the *will*. The heart, it is well to point out here, is one of the first organs to suffer from insufficient use of the entire body. The mechanism of this is interesting, and, since the fact is so important, it is worthy of description. The mass of blood, as has been described, is pumped by the heart into the great vessels which distribute it. Thus, the heart receives the blood and instantly pumps it out again. How, then, can the heart itself be nourished? In a state of normal tension of these larger blood vessels, the heart throws just enough blood at each beat to fill them to a point of normal fulness. This brings into play the elasticity of the vessel walls, which is very great. The supply of blood which goes to the heart comes to it by two small vessels whose opening is just beyond the limits of the heart muscle, and are called the coronary arteries. If the heart by any reason becomes over-weak, this impulse of the blood produces an insufficient reaction to press a needful supply into these little nutrient vessels, and hence they languish. Many disturbed states of the heart bring about this result. If the blood be not sufficiently oxygenated, an effect is wrought by this upon the heart muscle itself, and acting with it, the larger vessels. Thus is the vascular tension lowered and a progressive enfeeblement of the heart pump brought steadily about. Hence, the balance of the circulation is lowered in its most essential point. As the oxygen is supplied more abundantly and active movements effect this, the whole round of circulatory activities is invigorated. The heart not only itself becomes better nourished; it sends out at each beat a fuller measure of blood. This moves with a more per-

fect rhythm throughout the lesser vessels into and out of the tissues, and is finally returned to the right heart and thence to the lungs, where the respiratory need is also enhanced and re-oxygenation is made more perfect. Thus it will be easy to see how all the organs are enabled to do their duty better. But to organs long unaccustomed to this stimulus of abundant oxygen, the slightest muscular exertion causes palpitation and breathlessness. The lungs, unaccustomed to large demands upon them, can only bring into active use a limited proportion of their air cells, many of which have become collapsed and flabby, and are able only to expose a limited part of their area. Prolonged inactivity, too, enfeebles the eliminative power of the muscles. The sense of fatigue is greater, the distress of breathlessness likewise excessive, and all things combine to indispose one to effort. In short, the state of tissues in a man long unaccustomed to right activities, is simply that of filthiness, by retained poisons. All the tissues of the body, notably the most important one—the blood—all the larger glands whose function is chiefly that of excretion, are not only in a state of lowered activity, but contain longer than they should these poisonous by-products of digestion. Hence, these are enabled to exert their virulence upon the nerve centres, and all are measurably limited. To be sure, the marvellous adjustive power of the human organism enables one who becomes thoroughly accustomed to inactivities, to enjoy a very fair amount of health and to accomplish ample work. This is done, however, usually at considerable cost of discomforts, or by means of artificial aids of some kind.

Shocks to the heart mechanism are able to work damage. Rupture of its tendinous chords and valves have been caused by sudden and excessive strains. This is usually the result of inordinate efforts under the influence of fear or emotion. Also in one quite unused to muscular strains this may happen. Small evidence is adduced to show that this organ is ever damaged by reasonable strains in one even moderately well trained. It is rare enough among

laborers, iron workers, glass blowers, and such. Few athletic sports can be accredited with power to do so. The tug of war offers some danger and heavy weight lifting, dumbbell pulling, etc. Instances even here are rare. I wish to learn of all such, and will fairly sift and record them in future papers.

Let us look, then, upon the more attractive side of the picture, namely, the processes which are observed during exercise. Dujardin-Beaumetz says: "Under the influence of gymnastic exercises the activity of the cellular functions increases and becomes more regular, the intra-cellular combustions become more active, the leucomaines, those toxic materials which the organic cell is constantly manufacturing, are more actively eliminated, and the general effect is that the fats are burned up and the cellular functions regulated. There is established an equilibrium between the cells of the spinal cord and those of the brain; in a word, general nutrition becomes more active."

Indeed, all the cells of the body receive an increased stimulus from nerves and blood. Exercise, as pointed out, profoundly modifies the structure of the blood. During the actual process of muscular work that of dissimilation is made more active owing to the greater vigor of cell combustions, the muscle becomes actually hotter and destructible parts of it are burned up. This over-production of heat which accompanies work, and the vigorous combustion of the hydrocarbons of the body and their elimination from the system as waste products, cause loss of weight. This increase of combustion causes greatly increased respiration. The oxygen entering the lungs takes the place of that which is used in the combustion, and the final result is not actual loss, but at times a positive gain by reason of this gas. The recognizable loss of weight which occurs immediately after prolonged hard work is from elimination of watery elements through skin and lungs. Active exercise, then, introduces more oxygen into the system than is needed for the combustion. The difference between the arterial and venous blood of a man in perfect physical condition is in much more vigorous contrast than in the same

man during a period of inactivity. What the precise difference in weight of blood would be, it is impossible to know. The improved quality of the arterial blood, aside from the fact that it can place nutritive materials more valuably to the remoter tissues, does much more than this. The more nearly pure it be, and this property is almost altogether due to the completeness of its own oxygenation, so much more are the different kinds of cells in remoter parts of the body revivified.

So, also, are the products of cellular combustion more swiftly and efficiently taken up and carried back to the furnace of the lungs. There then comes as one of the most notable evidences of this improved state, a subjective sense of invigoration, which in itself is delightful. Muscular work, then, as a regulator of nutrition, is equally useful to those who do not assimilate enough and those who do not dissimilate sufficiently. Hence, very nearly the most clearly defined instinct, after that of searching for food, is to make movements of the body. If hunger for food or drink is the first instinctive appetite, assuredly the next is for those movements which enable us to keep our bodies still active. The appetite for food and drink can never be quite killed; the appetite for exercise dies hard, but if persistently thrust into abeyance it may almost go, especially in late age. Even among old people, however, in whom the taste for narcotics becomes highly developed, a desire for a daily walk is almost universally seen. In nearly all animals, however, of high or low degree, this appetite for movement is as recognizable as that for food and drink. It has never received a name, though really it deserves one. It might, perhaps, be called "air hunger."

When this vivifying oxygen is insufficiently supplied to the blood, its contact with the cells fails to give to them that needful stimulation which makes their working smooth and competent, and brings out their latent energies. Hence the appetite fails through insufficient stimulation of the digestive organs; the stomach and intestines lose their tone; the bowels become inactive, especially in places. These eddies in the bowel act as centres from which leuco-

maines and other putrefactive matters are more readily absorbed, instead of digested aliment, into the blood. Thence arise feelings of weakness; the muscles lose their irritability and respond less readily to the mandates of the will. In short, all the functions languish, and the human machine weakens. Again, the insufficient combustion of reserve materials remaining in the system, leads to disturbed states of health and actual disease. The most familiar of these is gout, as to which all of the human races and certain animals have some practical familiarity. But there are many similar conditions distressing enough, too, which arise from this cause. Indeed, among many animals this very disease is presented, and it is scarcely necessary to point to the wretched state of the over-fed, over-cared for inhabitants of zoölogical gardens, to see a picture ready at hand of the woes of forced inactivity.

*The Phenomena of Over-work.*—A muscle which has been induced to contract repeatedly at last reaches a condition which we call fatigue, and then under the stimulus alone of the will it cannot be made to further act. At first this is only relative. By passing an electric current through this muscle thus fatigued, it can be made to contract a certain number of times further, but finally there comes a period when the fatigue is absolute and the muscle has lost its power of contractility from any stimuli. The human muscle, however, never reaches this extreme point of exhaustion. The central consciousness is early made aware of this phenomenon by the sensation of pain. This pain finally becomes unbearable, and hence the muscular acts must be made to cease. This pain in muscle subject to over-contraction is the result of repeated shocks and disturbances occasioned in the mass itself and neighboring tissues. The muscle is traversed by a number of sensory nerve filaments. These little tendrils are rubbed and pinched by movements of the muscular fibres which swell and harden during the energetic contraction of work. These muscular fibres are themselves pulled about and the tendons and flat surfaces of insertion, the synovial membranes, undergo repeated friction. A positive injury, then,

is the local result of excessive muscular work, very similar to that which is produced from external causes such as bruises. Also in the body of the muscle itself modification of metabolism occur owing to the combustions which take place during contractions. Each muscle during contraction becomes heated, and this increase of temperature is due to the chemical combinations already described. These toxical agents affect the muscle itself directly and inhibit further contraction. If these are not formed in too great excess, they are readily carried away by the blood. If, however, the work is continued too long they accumulate in the muscle. There is, therefore, a vital process and a chemical one involved in local fatigue, each of which must be considered in judging of the result. Inherent muscular power may be never so great but that unless the domination of the will be sufficient to drive it, small results can come from its activity. Thus we see the instances of powerful animals whose mechanical powers are almost unimpaired, but who yet have had their will so dominated by that of another, or by the feeling of fear, that their tremendous machinery is made of no account.

*Per contra*, it is perfectly possible to apply a stimulus to the will of a dominated animal, or man, by which this machinery can be driven on and on to the point of profound exhaustion. This is often seen in horses and beasts of burden. Other factors come in here which we will describe later. It is rarely seen in man, however, although in some of the modern brutal exhibitions, such as long-walking matches, and the like, greed and vanity drive men to the limits of endurance and over into destructive effects.

The sense of fatigue which comes upon us as a subjective warning, enables our economy to learn in most instances quite clearly when we are overdoing or overdriving our powers. If we do err in pushing them yet further, this verges upon damage. During the expenditure of muscular force which is the result of automatic action, fatigue is much more slowly produced; hence, strictly speaking, a muscle with precisely the same inherent power can be made to do more work than if the tissue was strongly elicited.

Also automatic actions are less wastefully performed. There is a non-economical expenditure of force where an element of worry and mental strain comes in to complicate the process. A large series of muscles, however, is called involuntary. The structure of these, indeed, is somewhat different from the voluntary muscles. The movements of organic life, such as the heart beat and the respiratory movements, etc., are instances of this automatism. These organs never become fatigued; they may become exhausted, however. Under all reasonable and many unreasonable circumstances this wonderful pump, the heart, puts forth a force at each contraction of raising a weight of forty kilogrammes, one centimetre high, and does this sixty times to the minute, and continues this process from the cradle to the grave.

So, also, of the respiration. This complicated series of acts goes on without interruption throughout the entirety of life. Here, however, there is the double power of automatic action and direct volition, since we can increase the force or frequency of our breathing at will. It is extremely interesting to consider how widely individuals vary in their capacity to endure fatigue.

As I mentioned elsewhere, the quality of muscle differs considerably, but this is a little matter compared with the varying capacity of enduring the nervous strain in these nervo-muscular acts. Certain highly irritable natures are often readily exhausted, but if the stimulus to their minds be sufficient, these can be induced to make an output of energy which would far outstrip in results a cooler or more phlegmatic person. Also the results to them subjectively might be far more serious than to the phlegmatic person driven to do very nearly the same amount of work. In prescribing the amount and kind of bodily exercises, it is almost more important to weigh this question of temperament than any other single consideration. It is especially needful in persons of easily disturbed nervous balance to suggest the use of exercises which may not need sustained attention; certainly this at first, also, that these should be, as much as possible, automatic, until their powers warrant

larger excursions. One of the first sensations of discomfort which comes from unaccustomed exercises is loss of breath. To be sure, the breath is not lost, but many times the impression is given to us that it is, indeed, all but gone.

I remember very well that wise mentor Blaikie giving us upon the eve of a boat race, which was to be three miles long, this excellent counsel: "Now, boys," said he, "this is a three-mile race. Work steadily from the first. When you reach the second mile you will feel that your end has almost come. At about two miles and a half you will be sure that your breath has gone; but don't believe it. Always bear in mind the fact that every other man in your boat, and every other man in every other boat, feels precisely as you do. The man who works hardest in spite of all this, is the man who wins the race." Now, happily, a limit is put in all racing, both of man or beast, within the average capacity, a definite distance being fixed. Therefore, it is perfectly feasible to work up to the verge of your own conscious powers. We are subject to few more distressing feelings, however, than to the sense of breathlessness. This has been best described and, indeed, I am not so sure but also first described, by Lagrange: "Breathlessness is a feeling of distress which is produced during violent exercise or intense muscular work, and is characterized by an exaggeration of the respiratory need and by profound disturbance to the function of the respiratory organs. This state is merely a peculiar form of dyspnœa, and presents the general phenomena due to deficient aëration of the blood."

In certain muscular actions the distress comes in the shape of breathlessness, and in others, muscle contraction pain. For instance, in climbing up a ladder, hand over hand, a man must stop from sheer muscular incapacity long before he is out of breath. This is largely because the muscle is not properly trained to the act from long usage. In the act of running, however, a man must stop from sheer breathlessness long before his muscles are even tired. Here the explanation, too, is partly on the ground that the use of

the legs is almost incessant and they become inured to a vast amount of work.

Trainers say a horse trots with his legs and gallops with his lungs. It is necessary to distinguish between speed and gait. The act of galloping is one of the most natural movements to a horse. To do this slowly requires a peculiarly beautiful poise and grace. Horsemen will rate a horse's value under the saddle largely upon his capacity to gallop slowly; yet this is not necessarily so comfortable a gait to the animal in the long run as trotting. The trot is a much more artificial gait, and yet when once learned (for, indeed, it is largely the result of teaching), the pace can be maintained longer and with less distress.

Again, to quote from Lagrange: "In every muscular exercise the intensity of breathlessness is in direct ratio to the quantity of force expended in a given time. If certain exercises cause breathlessness more than others, this result is not due to special movements or particular attitudes which they occasion. The quick advent of breathlessness is not due to the contraction of certain muscles, to the displacement of certain bony levers, or to the mechanical disturbance which certain organs undergo during exercise: it is due to the rapid and excessive expenditure of force which the exercise necessitates." This respiratory distress is in a measure a defence against an imminent danger. When the blood becomes surcharged with carbonic acid, death may be caused in a few moments. This is the product of dissimilation resulting from vital combustion, and should be constantly eliminated by the lungs. It is possible to endure without hurt a definite amount of carbonic acid; poisoning beyond this point is dangerous. The presence of this poison in the blood causes us instinctively to draw in more and more air. The elimination of this product varies widely under different circumstances. The experiments of Regnault show that during the period of hibernation the carbonic acid output of an animal is but one-thirtieth when awake. Immediately on being awakened the need for oxygenation becomes imperative. During overactive movements in the open air there can be no dearth of

oxygen. Dyspnœa from exercise can only be the result, then, of the over-loading of the blood by this form of poison, of overcrowding the eliminative powers.

Other factors come in to produce this distressing phenomenon, among which may be mentioned the emotions. Under the influence of fear, breathing is noticeably disturbed. This is more readily seen among human beings, but also observed among hunted wild animals who are oftentimes readily captured if completely terrified.

[*To be continued.*]

## SOME ADDITIONAL NOTES ON THE GRAPHIC REPRESENTATION OF MAGNETIC FIELDS.

By Prof. Edwin J. Houston.

[*Addendum to a paper read before the Electrical Section of the Franklin Institute, June 28, 1892.*]

In a paper read at the last meeting of the Section, entitled "A Graphic Representation of the Magnetic Field," I described a process for readily fixing and reproducing the peculiarities of different magnetic fields, which consists essentially in forming the fields on wax-covered plates, subsequently fixing the same by gently warming the wax, and employing the plate so prepared as a positive from which photographic prints can be readily obtained.

I also briefly described in the same paper a different process for the ready reproduction of such fields, in which the collections of filings are formed in the dark photographic room, directly on the sensitized surface of a plate, which is afterwards exposed for a few seconds to actinic light and subsequently developed, and promised a further description of this method at this meeting.

It will readily be seen that this process differs from the other, in that it produces photographic negatives, in place of the positives formed by the former process.

Since the last meeting of the Section, I have experimented some little on the new process, and have obtained very satisfactory results.

For the convenience of those who have neither read the former paper, nor attended the meeting of the Section at which it was read, I will describe the process in full, together with the details which are necessary in order to ensure the best results.

All actinic light being excluded from the dark room, and the red light being turned down as far as will permit the plate to be seen, when the eyes have become accustomed to the dim light, a sensitized gelatine plate is placed with its sensitized surface upwards, on, or a short distance above, the magnet whose field is to be obtained. Iron filings or bits of wire are then carefully dusted over the sensitized surface, and obtained thereon, in characteristic groupings, by gently tapping the plate with a pencil or similar object in the usual manner.

The plate is then exposed to the light of a gas jet for a length of time that will of course depend on the nature of the plate, its sensitometer number, and the character of the effect it is desired to obtain.

When very rapid plates are used, the shortest time during which a gas burner can be turned on and off is sufficient. I have, however, obtained the best results from the light of an ordinary friction match held above the plate and at a distance from it of about twelve feet. The match is lighted and immediately blown out. Even this short exposure appears to be greater than is required. With fairly slow plates I have found that an exposure of about three seconds, with a two-candle gas jet, at a distance of about four feet from the plate, gives excellent results.

The plate is then turned on edge so as to allow the filings to fall off its surface, and any dust that remains is carefully removed by a camel's-hair brush, and the plate is developed in the ordinary manner.

Since it is desired to obtain sharp contrasts of black and white, the best results are obtained by the use of bromides in the developer for the purpose of retarding the rapidity of development. After developing, the plate is treated for a few moments to an alum bath, and is then fixed in the hypo bath as usual.

Should the depth of the negative thus obtained be insufficient, the plate may be subjected to the action of a suitable intensifier. I have found a silver intensifier to give good results.

The specimens which I exhibit to-night were obtained either from Carbutt's or from Seed's gelatine plates.

In some of these experiments, Carbutt's plates, sensitometer No. 16, were exposed for about three seconds to the light of an ordinary gas burner, turned down to about two candles, and situated about five feet from the plate. From some experiments in this direction I am inclined to believe that the time of exposure under these circumstances can advantageously be decreased.

I employed for these plates the following developer:

NO. 1.

| | |
|---|---|
| Water, | 16 ounces. |
| Sulphite of soda, | 307 grains. |
| Para-amido-phenol, | $76\frac{3}{10}$ " |

NO. 2.

| | |
|---|---|
| Water, | 16 ounces. |
| Sulphite of soda, | 307 grains. |
| Caustic soda, | 230 " |

Equal parts of Nos. 1 and 2 are mixed for use. For time exposure the above mixture is diluted with from two to four parts of water.

Any good developer, however, will answer.

I have also used Seed's plates, sensitometer No. 23. With these plates the momentary turning on and off of the gas jet gives a sufficiently long exposure.

I have also obtained very good results with Seed's plates sensitometer No. 26-x. With these plates my friend, F. Gutekunst, of Philadelphia, has prepared some excellent fields.

In order to protect the plates from the light of the gas jet while lighting it, so as to avoid too long an exposure, the expedient was adopted of covering the plate with a developing dish until the light was turned on. It was then exposed while the dish was being rapidly removed from the plate

the gas being turned off when the dish was about one and one-half feet distant from the plate.

While myself out of the city and, therefore, away from my laboratory, my friend, Mr. F. R. Lefferts, of the Celluloid Company, of New York, kindly placed a photographic dark room at his cottage, at Belmar, N. J., at my disposal during these experiments. I am also indebted to him for valuable aid in preparing the photographic plates.

*Fig. 1* shows the wire field of a straight bar magnet of steel. This corresponds to the bar magnet, the field of which was shown in the first paper on *Fig. 10*. This, like the other wire fields, was obtained by the use of short lengths of soft iron wire instead of iron filings.

*Fig. 2* shows the filings field of a simple horseshoe magnet. The anomalous poles in this magnet show very peculiar groupings in the neighborhood of what was originally the neutral point of the magnet. These poles were probably caused by some unauthorized juvenile experiments I had not counted on being made.

*Fig. 3* shows the field of two parallel straight bar magnets with their similar poles approached. This figure corresponds to *Fig. 5* of the first paper.

*Fig. 4* shows the field of two parallel straight bar magnets with their dissimilar poles approached. This figure corresponds with *Fig. 6* of the first paper. The conditions for the exposure of this field were more favorable than for most of the others, and the print shows what can be hoped for when the proper conditions necessary to ensure the best results are exactly understood.

Mr. Lefferts has kindly prepared for me an excellent transparency of this field, which I now show you.

*Fig. 5* shows the field produced by two straight bar magnets placed with their axes at right angles to each other, and with their similar poles approached. The characteristic parallel streamings, produced by the repulsion of similar lines of magnetized particles, are clearly shown.

*Fig. 6* shows the field produced by the straight bar magnets with their axes at right angles to each other and with their dissimilar poles approached.

*Fig. 7* shows the field of the two straight bar magnets placed with their axes at right angles to each other, and the pole of one near, but not in contact with, the neutral point of the other. This corresponds to *Fig. 4* of the first paper.

*Fig. 8* shows the filings field of a compound permanent horseshoe magnet. This figure corresponds with *Fig. 7* of the first paper.

*Fig. 9* shows a curious field of the same permanent horseshoe magnet shown in the former paper in *Fig. 9*. In this figure, however, the magnet is placed with its axis in a horizontal position, while in the figure of the first paper it was placed in a vertical position. I have reproduced *Fig. 9* of former paper in *Fig. 10* for ready comparison. The leakage, in planes at right angles, is well shown The magnetic leakage in this case gives the curious appearance of a "beatified bottle."

I also show you a number of aristotypes prepared for me by Mr. Lefferts.

I have formed some curious compound fields with filings and wire mixed. *Figs. 11* and *12* show such fields corresponding to *Figs. 3* and *4*, as shown above.

## AMERICAN ASSOCIATION OF STATE WEATHER SERVICES.

[*Summary of proceedings of the first meeting, held at Rochester, N. Y.*]

A convention of representatives of State Weather Services was held in Rochester, N. Y., on August 15 and 16, 1892, in conjunction with the forty-third meeting of the American Association for the Advancement of Science. The convention was called to order by Prof. Mark W. Harrington, Chief of the Weather Bureau, who made an address of welcome to the representatives present. He suggested certain important subjects for discussion, and appointed committees on permanent organization, programme, etc.

A permanent organization was effected, and the following officers were elected: President, Major H. H. C. Dun-

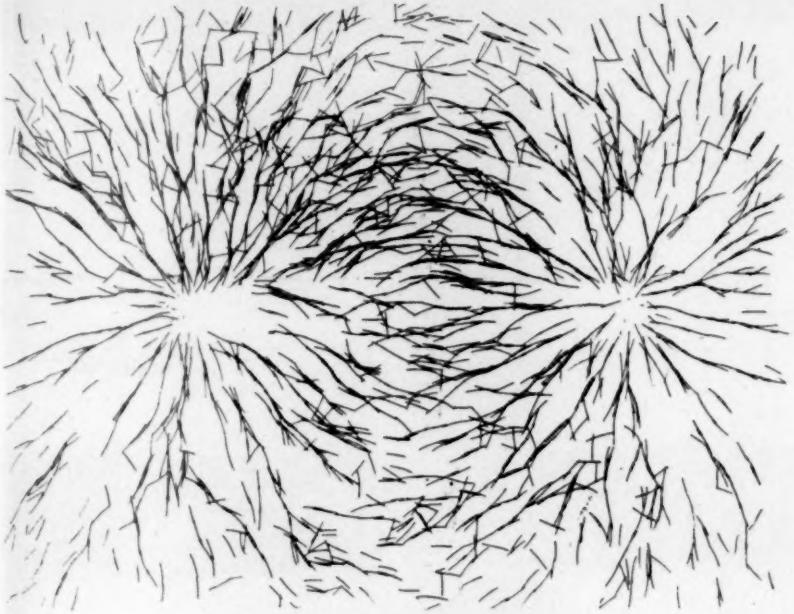

FIG. 1.—Wire Field of Bar Magnet.

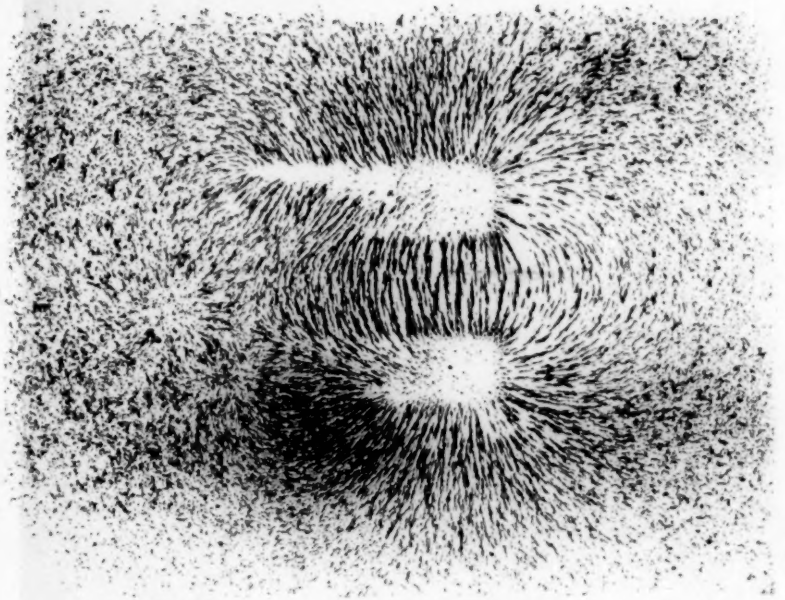

FIG. 2—Field of Simple Horseshoe Magnet.

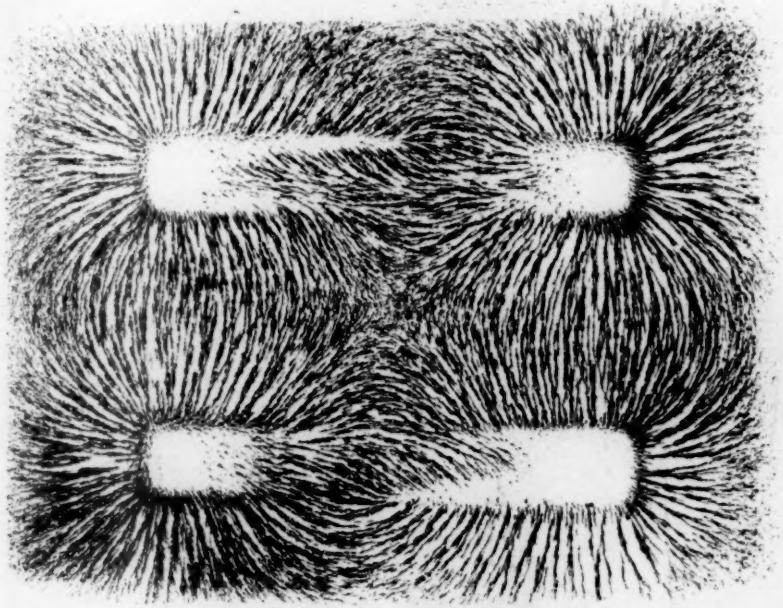

FIG. 4.—Field of Parallel Bar Magnets with Dissimilar Poles Approached.

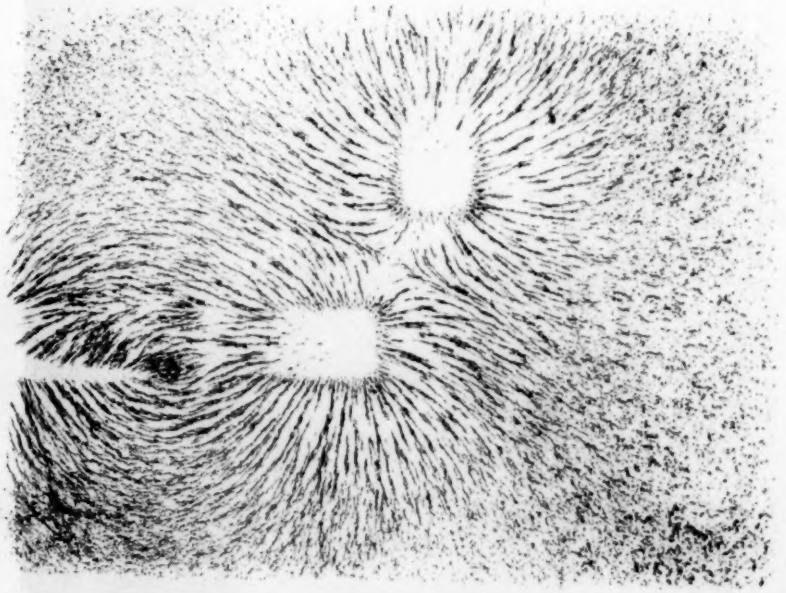

FIG. 5.—Field of Straight Bar Magnets with Axes at Right Angles and Similar Poles Approached.

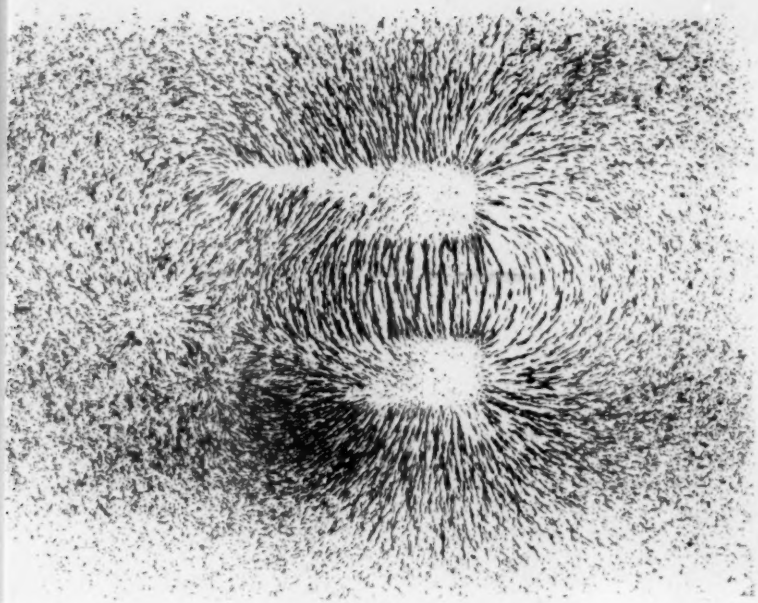

FIG. 2—Field of Simple Horseshoe Magnet.

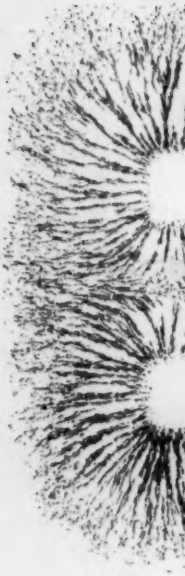

FIG. 3.—Field

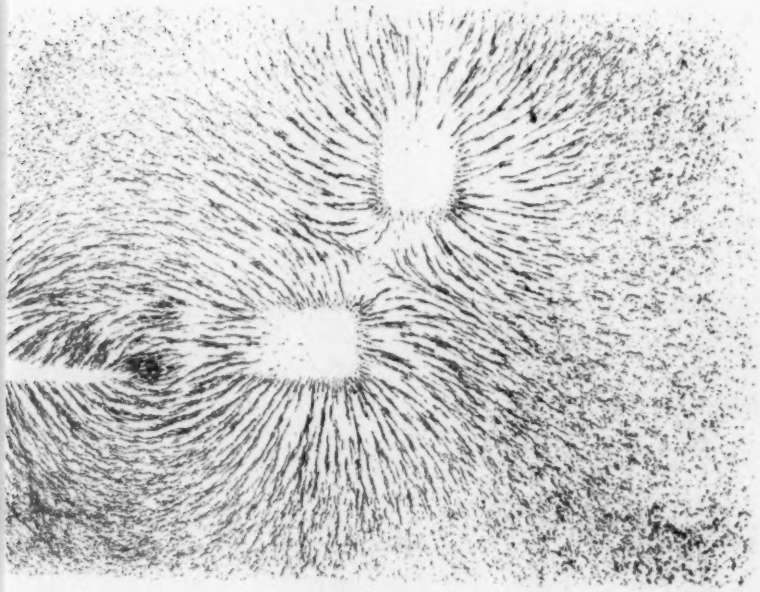

FIG. 5.—Field of Straight Bar Magnets with Axes at Right Angles and Similar Poles Approached.

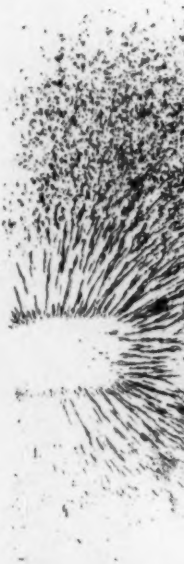

FIG. 6.—Field o

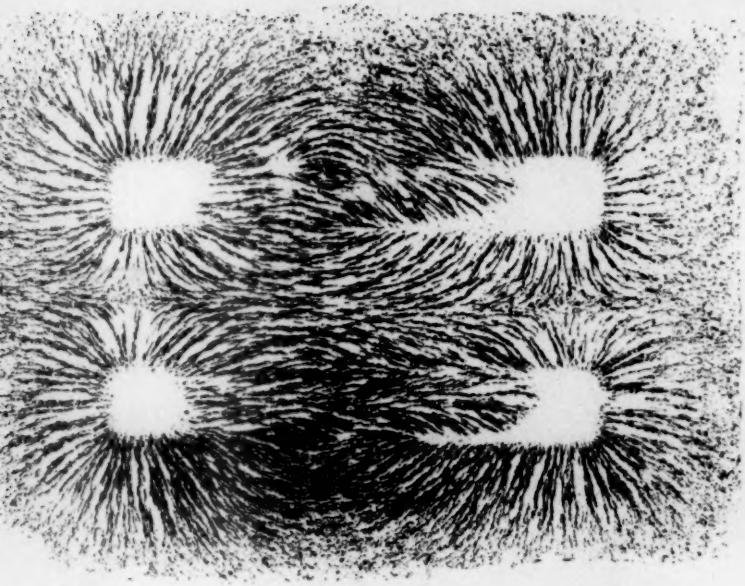

FIG. 3.—Field of Parallel Bar Magnets with Similar Poles Approached.

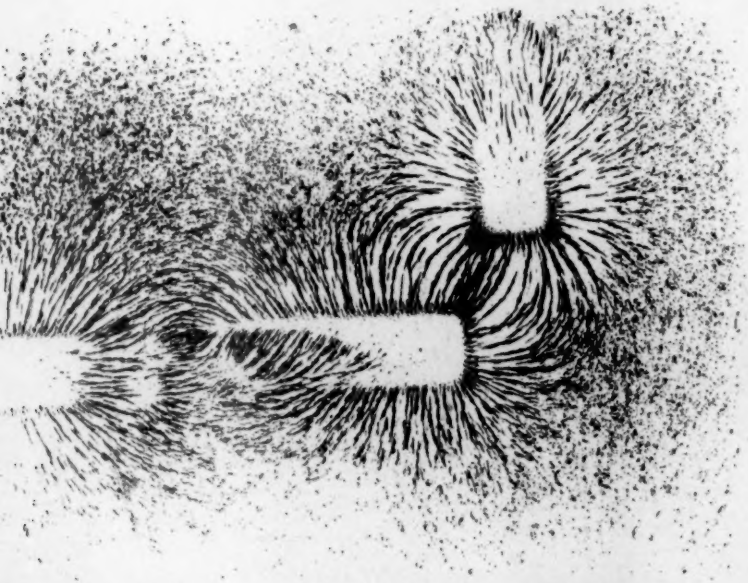

FIG. 6.—Field of Straight Bar Magnets with Axes at Right Angles and Dissimilar Poles Approached.

FIG. 7.

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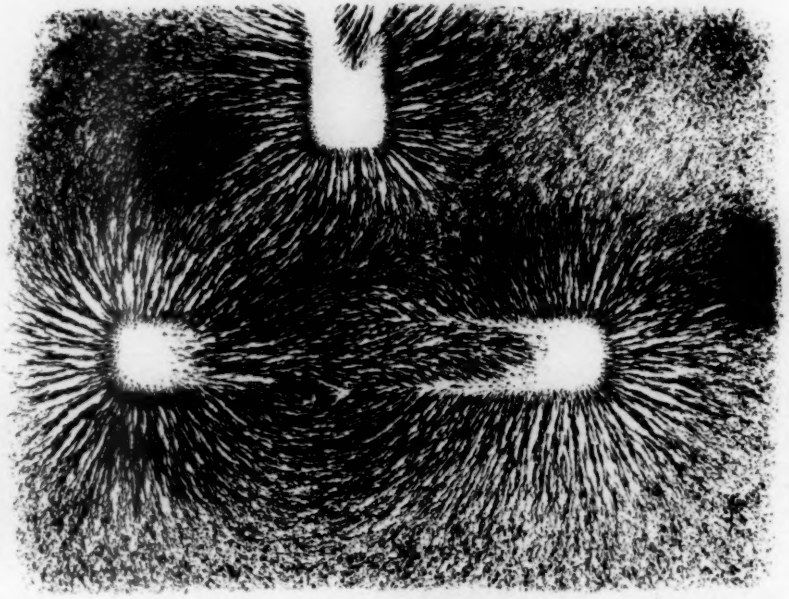

FIG. 7.—Field of Straight Bar Magnets with one Magnet near Neutral Point of the Othe·.

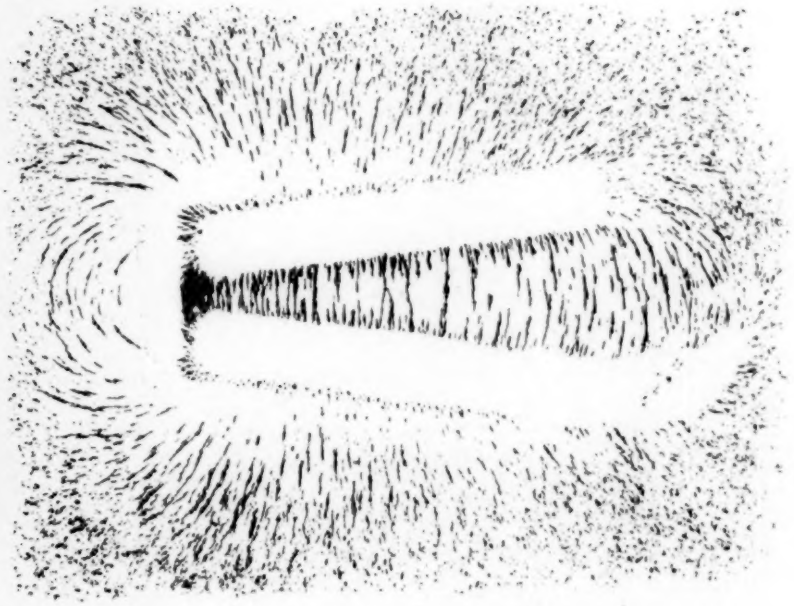

FIG. 8.—Filings Field of Simple Horseshoe Magnet.

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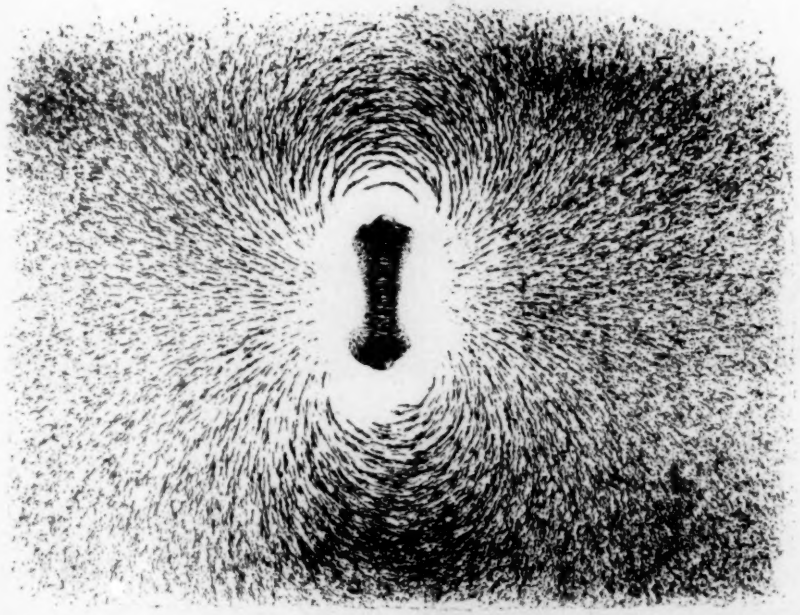

FIG. 10.—Field of Horseshoe Magnet with Longer Axis Vertical to Plate.

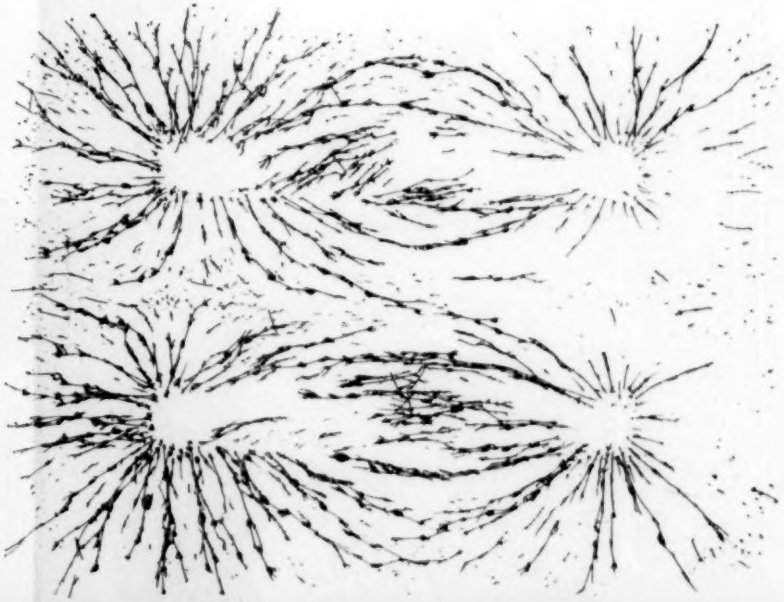

FIG. 11.—Compound Field of Parallel Bar Magnets with Similar Poles

FIG.

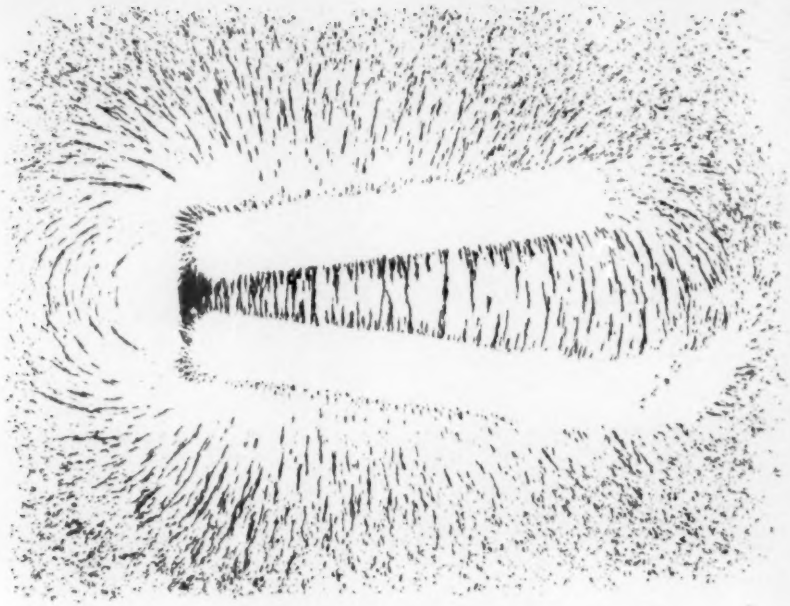

FIG. 8.—Filings Field of Simple Horseshoe Magnet.

FIG. 9

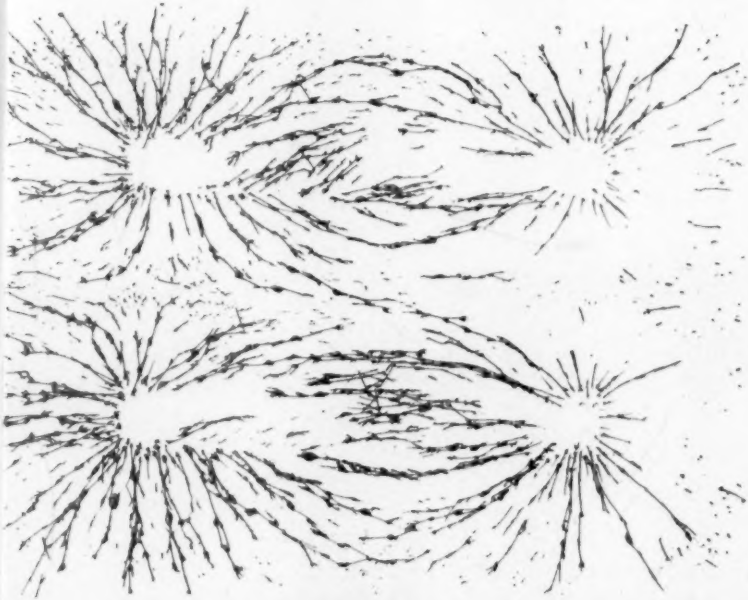

FIG. 11.—Compound Field of Parallel Bar Magnets with Similar Poles Approached.

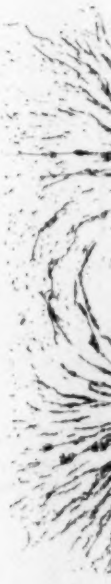

FIG. 12

(*Houston.*)

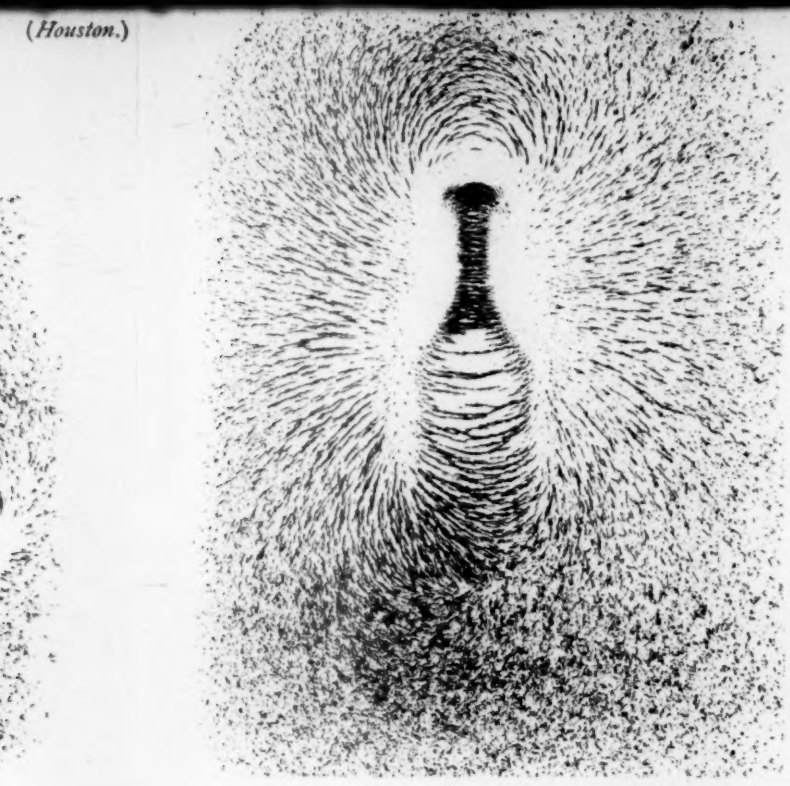

FIG. 9.—Field of Horseshoe Magnet with Longer Axis Horizontal to Plate.

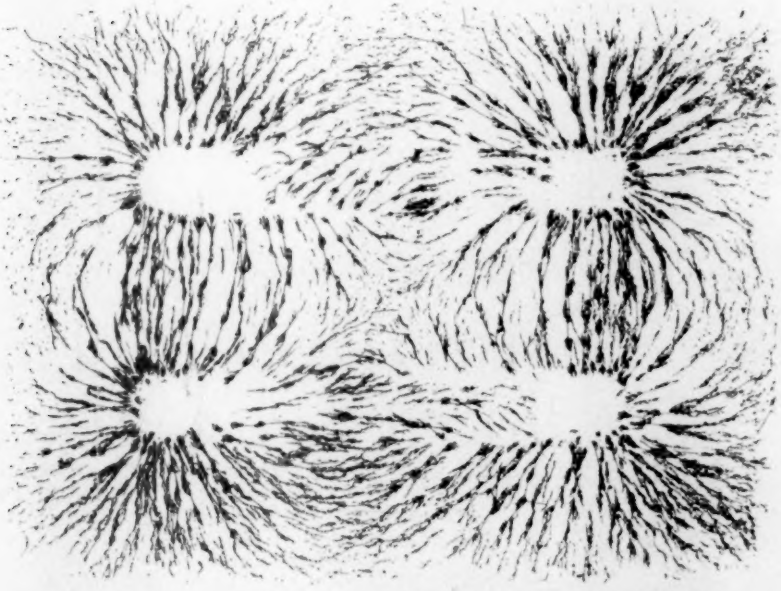

FIG. 12.—Compound Field of Parallel Bar Magnets with Dissimilar Poles Approached.

woody; First Vice-President, B. S. Pague, of Oregon; Second Vice-President, G. M. Chappel, of Iowa; Secretary, R. E. Kerkam, Chief of State Weather Service Division, Weather Bureau; and Treasurer, W. L. Moore, of Wisconsin.

The title, American Association of State Weather Services, was adopted by the convention, and it was decided to hold annual conventions in future at the same time and place as those of the American Association for the Advancement of Science.

The following representatives were in attendance: The U. S. Department of Agriculture, Weather Bureau, being represented by Prof. Mark W. Harrington, Chief; Major H. H. C. Dunwoody, Forecast Official; Mr. R. E. Kerkam, Chief of State Weather Service Division; Mr. N. B. Conger, Inspector, and Mr. F. J. Randolph, Stenographer. F. H. Clarke, Arkansas; J. A. Barwick, California; John Craig, Illinois; C. F. R. Wappenhans, Indiana; G. M. Chappel, Iowa; Frank Burke, Kentucky; E. A. Evans, Michigan; G. A. Loveland, Nebraska; J. Warren Smith, New England; E. W. McGann, New Jersey; R. M. Hardinge and W. O. Kerr, New York; C. M. Strong, Ohio; B. S. Pague, Oregon; H. L. Ball, Pennsylvania; S. W. Glenn, South Dakota; G. N. Salisbury, Utah; J. N. Ryker, Virginia, and W. L. Moore, Wisconsin.

Many of the representatives who were unable to be present at the convention forwarded papers, giving their views on various subjects of interest to be discussed.

The subject of instrument-shelters and a uniform manner of their exposure was debated, and it was the concensus of opinion that a uniform pattern of shelter should be adopted for use throughout the entire country. The subject was referred to a committee, consisting of Messrs. Smith, Moore and Pague, with instructions to report as to the most suitable shelter and manner of exposure to be generally adopted by State weather services.

On the subject of whether the voluntary observers should be supplied with self-registering maximum and minimum thermometers, the prevailing opinion was that such instruments should be issued, and used in determining

temperature means and averages wherever and whenever practicable. The old method of making readings at 7 A.M., 2 P.M., and 9 P.M. observations of the dry thermometer shall be continued whenever desired, but the means should be deduced from the self-registering thermometers where such instruments are in use.

As to the adoption of a form to cover the needs of a great majority of the voluntary observers who are supplied with dry or maximum and minimum thermometers and rain-gauge, it was decided to adopt a form which was suggested by the Secretary, so arranged as to admit of making three or four copies at one writing by means of the indelible carbon process, thus saving the observers the copying of the form at the end of the month; the object of this arrangement being to give a copy of the monthly report to the office of the Chief of the Weather Bureau, one to the office of the Director of the State Service, and one to be retained by the observer, and also to make such additional copies as he may desire to furnish to the local press, etc.

The forecasting of thunderstorms was the fourth subject discussed, and an interesting paper on this topic was read by the Wisconsin representative.

The proposition to print the weekly, monthly and annual reports of the State weather services in a uniform manner was freely discussed. The desirability of uniform reports was generally admitted, but it was thought impracticable at this time to take any action in the matter, as a number of States have appropriated funds for printing reports according to definite size and style.

The discussion of the question of the best methods of signaling weather forecasts by displaymen covered a wide range. The flag, the whistle, the semaphore, and the sphere, bomb, and flash-light systems were freely discussed, and an interesting paper was presented by the New England representative on the system of spherical bodies hoisted on a staff. This subject was referred to a committee composed of Messrs. Conger, Glenn and Kerkam, for report at the earliest practicable date.

On the subject of inspection of voluntary observers' stations the decision was that each voluntary station should be inspected at least once each year, to keep up the interest of the voluntary observers and to enable the directors of State services to become thoroughly familiar with each station and its surroundings. It was recommended by the association that sufficient leave of absence be granted the Weather Bureau representative at each State service centre to enable him to make a tour of inspection.

Relative to the subject, the relation of State weather services to Agricultural Colleges and Experiment Stations, it was decided that, owing to the lack of telegraphic facilities and other means of disseminating weather information, it would not be practicable, generally, to have the central stations of the State weather services at such colleges or stations, but that a very close co-operation would be desirable.

The subject of an exhibit at the World's Fair was the last general subject discussed. It was decided that each State service should have its exhibit in the building set apart for the use of the State, and not to have the exhibits collected in the building for the use of the United States Weather Bureau.

Mr. E. T. Turner, of New York, and Mr. E. H. Nimmo, of Michigan, were elected to active membership in the association, and the following honorary members were also elected: E. F. Smith, California; Prof. R. Ellsworth Call, Iowa; Chas. C. Nauck, Arkansas; Prof. Wm. H. Niles, Massachusetts; G. H. Whitcher, New England; H. G. Reynolds, Michigan; H. F. Alciatore, Oregon; Major Richard V. Gaines, Virginia; Prof. A. L. McRae, Missouri; C. F. Schneider, Michigan; Prof. Louis McLouth, South Dakota; and all active voluntary observers of the United States Weather Bureau.

After adopting resolutions of thanks to the American Association for the Advancement of Science and others for courtesies extended, the meeting adjourned *sine die.*

ROBERT E. KERKAM,
*Secretary.*

# CORRESPONDENCE.

## PATENT LAW AMENDMENTS.

*Ed. Franklin Institute Journal:*

The postponement to next Congressional session of Senate Bill No. 3246 affords opportunity for American inventors everywhere to examine its provisions, and, if dissatisfied with either of its eleven sections, to interrogate their respective Senators and Representatives on behalf of such modifications as they may think desirable. Section 1 especially seems worthy of their attention. Its ostensible purpose is the amendment of clause 2 of section 4887 R. S., by which, as is well known, the duration of a U. S. patent is made dependent upon that of the earliest expiring previously granted foreign patent for the same invention; but the amendment would seem to leave the most obnoxious feature of the clause substantially unchanged. Especially vexatious has the clause proved to the creators of those notable devices which, by inaugurating new arts and opening up hitherto untrodden fields of industry, constitute, to some minds, the chief justification of the patent system. If, as commonly supposed, our legistators aimed by the clause spoken of, to confer on their constituencies some kind of advantage over the foreigner, that aim has signally failed, the recoil of the weapon has proved far more disastrous than the discharge? Of patent-granting countries, ours is now admittedly foremost alike in the liberality of its patent-law and in the number and character of its useful inventions. The sum total of "aliens" prevented from exacting royalties on this side of the ocean is a mere *bagatelle* to the host of American inventors deprived, by this ill-advised clause of the revenue, of many millions that would have been drawn from the foreign user and circulated here; for it is notorious that a large majority of our inventors, rather than jeopardize their home patents, elect to forego the dangerous foreign privilege, with the result that American inventions are generally free to all except Americans. The present writer believes that the effect of the clause has been only evil and that continually and that the only proper amendment is to *expunge it*, or if that may not be, then let *American* ingenuity at least be relieved of this unmerited and unpolitic burden.

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